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# *The Research Quarterly*

**of the American Association for Health, Physical Education, and Recreation**

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# The Composite Criterion and its Relation to Factor Analysis

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THE FOLLOWING situation may arise: A student has available a number of variables, each of which is intended to measure some aspect or part of a more general characteristic or trait, and wishes to develop a "criterion" from them. He chooses a weighting scheme, combines the weighted scores for each of the variables into a single composite, and uses this composite as a criterion. Such a practice is illustrated in a recent paper by McHone, Tompkin, and Davis (4).

We shall use this article to illustrate the points above; it should be emphasized that censure is not intended, since there is nothing "wrong" in developing and using such a composite. Instead, the purpose of this paper is to call attention to a well-known fact; namely, that if the inter-relationships of the set of independent variables are of rank greater than one, e.g., if these inter-relationships are functions of more than one common factor, this composite criterion represents only *one of several factors* (3).[1] In fact, if the independent variables are combined with equal weights as they are when standard scores are added, the correlation of each of the independent variables with the composite criterion is given directly by the correlation of that variable with the first centroid factor of the complete matrix of intercorrelations of the independent variables. We shall illustrate this in Table 1.

Consider a set of test scores in standard ($z$-score) form. The correlation between any two variables is given by pairing two standard scores for each person, multiplying, summing, and dividing by $N$ (the number of persons). In effect, the product-moment correlation is an average of the paired products of the standard scores. Similarly, the variance (square of the standard deviation) of each set of standard scores is given by squaring the standard score of each person, summing, and dividing by $N$. This variance is of course equal to unity. The complete matrix of intercorrelations of the variables with unity in each of the diagonal cells is thus given by this systematic multiplication of standard scores by themselves, followed by an averaging. Therefore, it is reasonable to expect that when the standard scores for each person are summed to give a "new" variable, or composite, the correlation of this composite with each of the variables will be some function of a sum of the complete correlation matrix.

[1] The concepts of factor analysis are given in many texts. A comprehensive one is reference 2.

Take as a trivial numerical example these standard scores for four persons on three variables:

| | Persons | | | |
|---|---|---|---|---|
| | a | b | c | d |
| Variable 1 | +1 | +1 | −1 | −1 |
| Variable 2 | +1 | −1 | −1 | +1 |
| Variable 3 | −1 | −1 | +1 | +1 |
| Sum | +1 | −1 | −1 | +1 |

Multiplying these standard scores together and then averaging (dividing by 4) gives as the complete correlation matrix:

| | Variable | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Variable 1 | +1 | 0 | −1 |
| Variable 2 | 0 | +1 | 0 |
| Variable 3 | −1 | 0 | +1 |
| Sum | 0 | +1 | 0 |

Note that the sum of this correlation matrix is exactly equal to the correlation of the sum of the variables, i.e., the composite criterion, with each of the three variables. We shall return later to this illustration.

Consider some "real" data. McHone, Tompkin, and Davis report that they weighted standard scores equally to derive their composite. They say:

"... it was believed that a composite score from all tests would serve as an adequate criterion (Cozens, 1) of physical ability. The modified *T*-score method was then employed to make up point scores for each item. ... To arrive at a composite score, the point scores from all tests were added together, using the best performance of each subject." (4, *pp. 83, 90*)

They then correlated this composite or sum of standard scores with each of the 19 independent variables. Their results are given in the third column of Table 1.

The point of view of factor analysis suggests that we should be able to reproduce these correlations with very little calculation by extracting the first centroid factor. To do this, we inserted units in the diagonal cells of their 19-by-19 correlation matrix, and summed each column of this correlation matrix to secure the numbers in the first column of Table 1. These sums were summed, and the square root of this number (113.684) used as a divisor of each sum to give the numbers in the second column of Table 1. These are the correlations of each of the 19 variables with the first centroid factor of the complete correlation matrix.

The agreement of the second and third columns of Table 1 should be noted. We cannot explain the few discrepancies that appear; it may be that there are some slight errors in the published correlations, or it may be that the method of choosing the best performance of several trials in developing the composite

introduced these differences. The point, however, is clear. Summing the columns of the complete correlation matrix and then dividing by the appropriate constant gives directly, and with very little calculation, the correlations of each variable with the equally-weighted composite of all the variables.

TABLE 1

*Comparison of the Correlations with the First Centroid Factor and the Correlations with the Composite Criterion*

| Variable | Sums of columns of complete correlation matrix | Correlation with first centroid factor | Correlation with composite criterion |
|---|---|---|---|
| 1 Squat twist | 7.878 | .739 | .724 |
| 2 Sitting medicine ball throw | 6.890 | .646 | .690 |
| 3 Standing broad jump | 6.703 | .635 | .686 |
| 4 Push shot | 6.956 | .652 | .686 |
| 5 Wall bounce test | 6.901 | .647 | .651 |
| 6 Standing medicine ball throw | 6.316 | .592 | .645 |
| 7 Potato race | 7.016 | .658 | .644 |
| 8 Block transfer | 7.125 | .668 | .637 |
| 9 Block transfer | 6.924 | .649 | .621 |
| 10 Squat-stretch | 6.952 | .652 | .609 |
| 11 Circle scramble | 6.493 | .609 | .598 |
| 12 Combined speed test | 6.712 | .629 | .591 |
| 13 Vertical jump | 5.865 | .550 | .570 |
| 14 Block balance | 4.836 | .454 | .452 |
| 15 Hand transfer | 4.635 | .435 | .407 |
| 16 Chinning | 4.791 | .449 | .357 |
| 17 Dipping | 4.708 | .442 | .344 |
| 18 Bent arm hang | 3.364 | .315 | .246 |
| 19 Leg raiser | 2.549 | .239 | .199 |
| Sum | 113.684 | | |

The meaning of this composite criterion should be considered. It is, from the point of view of factor analysis, the first centroid factor. As such, it is not necessarily either a "complete" criterion or the "best" criterion. It is not "complete" if the matrix of intercorrelations of the independent variables is of rank greater than one, i.e., demands more than one common factor to represent these relationships. It is obvious, for example, in the hypothetical numerical example given above, that the composite is identical with variable 2, and does not, in any sense, "represent" variables 1 and 3, even though it was secured by summing all three variables. This hypothetical correlation matrix is precisely of rank two, and therefore demands two factors to account for the interrelationships of the variables. The second factor would have correlations of plus 1 with the first variable, zero with the second variable, and minus 1 with the third. These two factors[2] would then reproduce the correlation matrix exactly. If one wished, he could then determine the factor scores corresponding to these two factors and use them as two independent and uncorrelated composites.

It may seem strange that summing a set of standard scores does not necessarily provide all the information contained in the scores themselves. The concept of dimension is relevant here. Sets of test scores may be thought of or

[2] It so happens these are principal-axis factors.

represented as vectors in space. In the hypothetical example, the three tests considered as vectors occupy a "two-space" or a plane. Two of the vectors (variables 1 and 3) are colinear, that is, one is simply an extension of the other, as is indicated by the minus 1 correlation between variables 1 and 3. The other vector (variable 2) is at right angles to this line, that is, its correlation with variables 1 and 3 is exactly zero. Summing the standard scores to secure a single composite is the attempt to represent these three vectors in a one-space or a single dimension. It is clear that representing a plane by a single line necessarily "loses" something of the original character of the plane. This is what happens when a single composite is used to represent variables that lie in a space greater than one. The single composite is a "new" vector that is merely a linear combination of the original vectors. Since it is a single vector, it lies in a space of dimension one, which is only a part of the total space occupied by the original vectors. For completeness, then, one needs as many composites as the dimensionality of the space in which the original test vectors lie, i.e., as many as the rank of the correlation matrix, which necessarily is the same as the rank of the score matrix.

Such a generalization introduces a practical problem, since with most sets of actual data the rank of the complete correlation matrix is equal to the number of variables. If so, this would demand as many composites as variables for completeness, and one might conclude sensibly that he might as well use each of the original variables. However, it often happens that a relatively few factors are sufficient to reproduce, approximately, the intercorrelations of many variables, even though these factors do not account for all the variance of the variables. If so, one may be satisfied to take this relatively small number of factors as a practical solution to the problem of the number of composites to be considered. The correlation of each of the independent variables with each factor, i.e., each criterion, and the weightings to be applied to the original scores to obtain each of the composites can then be computed.

It was also suggested that the first centroid is not necessarily the "best" criterion. This is a rather technical point, and is not of great practical importance. However, it is true that if one wishes to account for the maximum possible amount of the given variance by means of a single factor, he should extract the first principal-axis factor rather than the first centroid. The first centroid is a first approximation to the first principal axis, however, and with actual data often differs from it only trivially.

So far, some of the elementary concepts of factor analysis have been related to the rather common practice of developing a composite criterion. This point of view suggests that if the given variables have a well-defined factor pattern, it may be most meaningful to develop those composites associated with the identified factors. This would demand an analysis of the inter-relationships of the given variables to identify the factors and then the computation of the factor scores associated with these factors. Another value of this approach is that it may enable the student to test some of the "hunches" he, or others, have about the organization of the variables he is using. Again, the recent work by McHone, Tompkin, and Davis is used for illustration since they present in detail their classification of the variables. We shall use a factoring technique to

analyze the inter-relationships of the variables and then compare our results with their *a priori* classifications.

A multiple-group method of factoring and an oblique solution were chosen (1). The obtained pattern was transformed into correlations with the simple axes and a few radial rotations made to secure a large number of correlations within the +.10 to −.10 range. The results are given as Table 2. Since this is an oblique solution, the factors are correlated. The intercorrelations of the primary factors are given in Table 3. Two residual matrices are given in Table 4. The entries below the diagonals are the correlations remaining after the extraction of the seven factors. It will be seen that most of these residuals are small enough to be judged, on a practical basis, as insignificant. The underscored residuals above the diagonals are the correlations remaining after the extraction of the first centroid. It will be seen that several substantial correlations still remain after this first centroid has been extracted.

TABLE 2

*Oblique Factor Matrix—V**

| Variable | A | B | C | D | E | F | G | Centroid $h_j^2$ | M·G $h_j^2$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 075 | −031 | 045 | 464 | 149 | 075 | 105 | 546 | 686 |
| 2 | 615 | 070 | 147 | −058 | 040 | 109 | 197 | 417 | 754 |
| 3 | 123 | 002 | −035 | −036 | 473 | 034 | 167 | 403 | 641 |
| 4 | 545 | 018 | −043 | 079 | 198 | 241 | 142 | 425 | 764 |
| 5 | 386 | 240 | −043 | 192 | 098 | 188 | −055 | 419 | 672 |
| 6 | 647 | −036 | 145 | 091 | −038 | −061 | 181 | 350 | 778 |
| 7 | 017 | 572 | 023 | 035 | −025 | −042 | −027 | 433 | 778 |
| 8 | −017 | 451 | −023 | −035 | 025 | 042 | 027 | 446 | 586 |
| 9 | −017 | 040 | 019 | −063 | 046 | −017 | 569 | 421 | 666 |
| 10 | −010 | 095 | 023 | 531 | 067 | 004 | −070 | 425 | 677 |
| 11 | 052 | 251 | −049 | 158 | 174 | 232 | −033 | 371 | 413 |
| 12 | 017 | −040 | −019 | 211 | −046 | 017 | 462 | 396 | 566 |
| 13 | 030 | −002 | 050 | 036 | 546 | −034 | −066 | 303 | 593 |
| 14 | −043 | −006 | −050 | −023 | 321 | 311 | 159 | 206 | 291 |
| 15 | −066 | −064 | −068 | 455 | −064 | −078 | 117 | 189 | 391 |
| 16 | 005 | 094 | 685 | −056 | 062 | 048 | −072 | 202 | 905 |
| 17 | −005 | −094 | 561 | 056 | −062 | −048 | 182 | 195 | 675 |
| 18 | 138 | −044 | 284 | 031 | 040 | 409 | 019 | 099 | 458 |
| 19 | −049 | 044 | 067 | −031 | −040 | 478 | 163 | 057 | 458 |
| Number of variables between ±10 | 13 | 15 | 14 | 13 | 13 | 12 | 8 | | |

* Decimal points have been omitted.

TABLE 3

*Intercorrelation of Factors—$\phi$*

| Factor | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| A | 1.000 | | | | | | |
| B | .208 | 1.000 | | | | | |
| C | −.429 | .046 | 1.000 | | | | |
| D | −.022 | .577 | .104 | 1.000 | | | |
| E | .319 | .081 | .139 | .101 | 1.000 | | |
| F | −.391 | −.096 | .402 | .102 | −.292 | 1.000 | |
| G | −.077 | .500 | .209 | .411 | −.092 | .052 | 1.000 |

TABLE 4

*Residual Matrices**

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | − 127 | −038 | −059 | −012 | −042 | 007 | −054 | −042 | 184 | −091 | 051 | −025 | −092 | 118 | −094 | −023 | −038 | −077 |
| 2 | 002 | | 090 | 254 | 165 | 385 | 007 | −042 | −068 | −171 | −002 | −066 | 008 | −054 | −218 | −203 | −203 | −123 | −207 |
| 3 | 003 | −004 | | 114 | −027 | 154 | −081 | −010 | −001 | −147 | −085 | −033 | 233 | −041 | −102 | −091 | −129 | −178 | −219 |
| 4 | −014 | −043 | −011 | | 234 | 350 | −011 | −040 | −055 | −080 | 028 | −113 | 060 | −201 | −127 | −296 | −307 | −065 | −256 |
| 5 | −020 | −002 | −028 | 011 | | 176 | 132 | 062 | −131 | 018 | −075 | −098 | −009 | −107 | 024 | −310 | −300 | −138 | −182 |
| 6 | 034 | 029 | 044 | 026 | −026 | | −027 | 010 | −048 | −127 | −074 | −047 | −022 | −111 | −146 | −271 | −277 | −294 | −233 |
| 7 | 015 | 018 | 004 | 017 | 000 | −035 | | 220 | −002 | 069 | 034 | −006 | −116 | −147 | 035 | −147 | −170 | −175 | −188 |
| 8 | −015 | −018 | −004 | −017 | 000 | 035 | 016 | | −011 | 037 | 057 | −029 | −017 | −116 | −053 | −098 | −155 | −216 | −094 |
| 9 | 001 | −029 | −028 | 028 | 014 | −012 | 006 | −005 | | −073 | −056 | 152 | −040 | −023 | −053 | −020 | 051 | −135 | −017 |
| 10 | 021 | 019 | −031 | 016 | −031 | −005 | −025 | 025 | 033 | | 118 | −001 | −038 | −155 | 169 | −117 | −086 | −120 | −054 |
| 11 | −103 | 077 | −009 | 045 | −134 | 012 | −032 | 032 | 055 | 060 | | −115 | −058 | −064 | 037 | −115 | −118 | −069 | 021 |
| 12 | 000 | 029 | 029 | −028 | −014 | 013 | −005 | 006 | −004 | −033 | −055 | | −166 | −050 | 131 | −126 | 025 | −079 | −026 |
| 13 | −003 | 004 | 005 | 011 | 028 | −044 | −004 | 004 | 029 | 031 | 009 | −029 | | 065 | −155 | −004 | −047 | −107 | −257 |
| 14 | −046 | 061 | −050 | −134 | 016 | 055 | 020 | −020 | 000 | −057 | −017 | 000 | 050 | | 004 | 088 | 011 | 051 | 143 |
| 15 | −005 | −021 | 029 | −001 | 052 | −028 | 010 | −010 | −033 | −014 | 043 | 034 | −028 | 103 | | −163 | −111 | −137 | −065 |
| 16 | −018 | −006 | 012 | 005 | −020 | 021 | −007 | 006 | 014 | −006 | −021 | −015 | −013 | 023 | 024 | | 585 | 407 | 183 |
| 17 | 018 | 006 | −013 | −005 | 020 | −021 | 007 | −007 | −015 | 006 | 021 | 015 | 013 | −023 | −025 | 055 | | 192 | 253 |
| 18 | 021 | 002 | −016 | 062 | 011 | −076 | 040 | −041 | 019 | −021 | 006 | 019 | 016 | −042 | −001 | 057 | −057 | | 333 |
| 19 | −021 | −002 | 016 | −062 | −011 | 076 | −041 | 041 | −019 | 021 | 031 | −019 | −016 | 042 | 001 | −057 | 057 | −050 | |

*Decimal points have been omitted. Underscored entries are residuals after the extraction of the first centroid. Entries below the diagonals are residuals after the extraction of seven factors.

Ordinarily, having secured a factor solution judged to be satisfactory, one "names" the factors. We shall not do that here. The reader may wish to stop at this point, examine the data on Table 2, and attempt to develop for himself a set of names that he feels describes these factors adequately. Instead, we shall present the groupings of variables that have substantial correlations with each factor and the classifications of these variables made by the authors.

| Factor A | Correlation with factor | Classification |
|---|---|---|
| 6 Standing medicine ball throw | .647 | Explosive power of arms, strength of back and shoulder girdle extensors, and general coordination |
| 2 Sitting medicine ball throw | .615 | Explosive power of arms |
| 4 Push shot | .545 | Explosive power of arms |
| 5 Wall-bounce test | .386 | Hand-eye coordination and speed |
| **Factor B** | | |
| 7 Potato race | .572 | Agility and speed |
| 8 Dodge run | .451 | Agility and speed |
| 11 Circle scramble | .251 | Agility and coordination |
| 5 Wall-bounce test | .240 | Hand-eye coordination and speed |
| **Factor C** | | |
| 16 Chinning | .685 | Strength and endurance of shoulder girdle |
| 17 Dipping | .561 | Strength and endurance of shoulder girdle |
| 18 Bent arm hang | .284 | Endurance and strength of arm flexors |
| **Factor D** | | |
| 10 Squat-stretch | .531 | Agility and speed |
| 1 Squat twist | .464 | Body agility, coordination |
| 15 Hand transfer | .455 | Hand-eye coordination |
| 12 Combined speed test | .211 | Speed of muscular contraction of arms and legs |
| **Factor E** | | |
| 13 Vertical jump | .546 | Explosive power of legs |
| 3 Standing broad jump | .473 | Explosive power of legs |
| 14 Block balance | .321 | Balance |
| **Factor F** | | |
| 19 Leg raiser | .478 | General strength and endurance |
| 18 Bent arm hang | .409 | Endurance and strength of arm flexors |
| 14 Block balance | .311 | Balance |
| 4 Push shot | .241 | Explosive power of arms |
| 11 Circle scramble | .232 | Agility and coordination |
| **Factor G** | | |
| 9 Block transfer | .569 | Agility and hand-eye coordination |
| 12 Combined speed test | .462 | Speed of muscular contraction of arms and legs |

This comparison sets certain problems. To some extent the *a priori* classification is consistent with the operational classification given by the factor analy-

sis. For example, the terms agility and speed were used primarily to describe variables that clustered only on Factor B; a noticeable exception is variable 10, the squat-stretch, which appears on Factor D. On the other hand, the terms used to describe the variables clustering on Factor F have no obvious common denominator. Instead, Factor F appears to have grouped variables which may well be centered around some form of abdominal strength although no such term was used in the initial classification. One other example seems outstanding. No balance factor was obtained, even though variable 14 (block balance) is included in the matrix. Evidence seems to be present, however, that such a factor might have been identified if more variables of body balance had been included in the matrix. There is a small doublet left in the residual matrix for variables 14 and 15; this suggests an unanalyzed linkage which may be an ability to balance the body.

In addition, the communality of variable 14 in Table 2 indicates that block balance still has considerable variance not accounted for in this analysis. Block balance has appeared, however, on factors E and F. Factor E has grouped the tests labeled explosive power of the legs, and Factor F has grouped variables which we believe involve some form of abdominal strength. Neither of these terms were used in classifying variable 14. Thus, factor analysis has indicated that other components are operating in this variable which were not readily anticipated by an *a priori* classification.

**Summary**

In summary, it has been the purpose of this paper to emphasize some of the functions which factor analysis may have in studying physical activity. One of the points emphasized has been that of relating some of the elementary concepts of factor analysis to the practice of developing a composite criterion. It has been suggested that if a well-defined factor pattern exists, then, for completeness, several composites should be developed. Attention was called to the fact that a composite attained by averaging scores of all variables represents only one factor. Another point emphasized has been that of the use of factor analysis to test certain hypotheses about the operational organization of a set of variables. An *a priori* classification provides "hunches" or hypotheses about the components that are operating. However, components that may be quite important in understanding the variables and the individual differences in motor performance that they reveal may be overlooked unless a systematic analysis of inter-relationships is made.

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# Beginning Badminton Written Examination

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FOUR YEARS AGO the Women's Physical Education Department at the University of Washington organized, in several different activities, sports committees whose purpose was to standardize and improve the teaching and grading in these activities.

The Badminton Committee,[1] appointed in the spring of 1949, has outlined course content both as to skill and knowledge, and has written analyses of strokes and techniques used in beginning badminton classes. It also has been working on an objective, reliable, and valid means of evaluating the knowledge of students in beginning classes.

It is the purpose of this article to present a statistical analysis of a knowledge test for college women students in beginning badminton classes.

## Procedure

At the end of fall quarter, 1950, an experimental objective written badminton examination was given to students in beginning badminton classes. This examination had been constructed on the basis of the material that the Badminton Committee had listed in Course Content.

The criteria for a good test were given careful consideration in the wording of the questions and in the technical make-up of the examination. There were questions dealing with analysis of strokes, strategy, rules and scoring, terminology, and court lines and areas. The test consisted of 90 responses grouped into the following question types: multiple true-false, multiple choice, true-false, short answer, and identification of court lines and areas.

The examination was duplicated and given to 89 students in beginning badminton classes. They were asked to make notations on any questions which they felt were ambiguous, not clearly stated, or which they could not understand. Also, the instructors were asked to keep a record of any questions asked them about any item in the examination.

The reliability of the entire examination and the validity and difficulty of each item were computed. In the light of these findings, certain questions were re-worded, put into different question types, deleted, and other items were added to form a new examination of 107 responses. The multiple-choice section was deleted completely because the questions in this section did not discriminate between the high and low students.

This revised examination was given to 269 students at the end of one quarter's instruction in a beginning badminton class winter quarter, 1951. The

[1] Other members of the Badminton Committee are: Helen Clark, Kathro Kidwell, Helen McLellan, Leone Rulifson, Ellen Waters, and Virginia Wolf.

following were computed on this revised examination:

1. The reliability of the entire examination
2. The validity of each item
3. The difficulty of each item

The results indicated that 80 of the questions on this revised examination discriminated at a sufficiently high level of significance to be useful in the final form of the examination. Accordingly, there was constructed a third examination which incorporated these 80 questions and which included 26 additional responses. This third examination was given to 124 students in beginning badminton classes at the end of fall quarter, 1951, and to 219 students in beginning badminton classes at the end of winter quarter, 1952.

### STATISTICAL ANALYSIS OF THE EXAMINATIONS

*Distribution of Scores.* A frequency distribution of the scores was made and the mean and standard deviation were computed.

*Reliability.* The reliability was determined by the use of the split-halves method and the Spearman-Brown formula.

*Curricular Validity.* To assure curricular validity the following procedures were followed in the construction of the examination.

1. Test items included were determined by the course content as outlined by the Badminton Committee. This course content and the technique analyses were based on the opinion of experts and on the literature dealing with badminton, and were accepted by all of the badminton instructors. Therefore, all material covered in the examination had been included in the curriculum.
2. An attempt was made to have the percentage of test items dealing with each area correspond as closely as possible with the emphasis placed on these phases in the course of study.

*Item validity.* The item validity was determined by the upper-lower thirds method. Test papers were divided into upper, middle, and lower groups according to total score. The percentage of each group that missed each question was determined. The percentage of the high and low groups missing each question were compared and the phi[2] determined. The phi coefficients necessary for a group of this size to indicate discrimination at the 1-, 2-, 3-, and 5-per-cent levels were calculated.

*Item Difficulty.* The difficulty of each item included in the examination was determined by computing the percentage of the total group that missed each question.

## Discussion of the Results

### DISTRIBUTION OF SCORES

The scores on the test ranged from five errors to 62 errors. The mean score was 25.05 with a sigma of 10.82. The distribution of the scores was such that the examination has proved useful in assigning knowledge grades.

[2] C. E. Jurgenson. Table for determining phi coefficients. *Psychometrika*, **12:** 17–29 (March 1947).

RELIABILITY

With each revision of the examination the reliability improved. The reliability computed for the examination given to 89 students fall quarter, 1950, was .78 ± .028. For the examination given to 269 students winter quarter, 1951 the reliability was .80 ± .015. When the final form was given to 124 students fall quarter, 1951, the reliability was found to be .90 ± .012; and when these results were combined with those from 219 students winter quarter, 1952, the reliability was found to be .88 ± .008. There are still a few questions which do not discriminate. If these were replaced by questions which discriminate at a high level of significance an even higher reliability could be expected.

CURRICULAR VALIDITY

In the final form of the examination 31 questions (29%) deal with analysis of strokes and techniques; 41 (39%), with rules and scoring; 11 (10%), with strategy; 23 (22%), with terminology. This weighting does not agree entirely with the relative emphasis placed on these various phases in the course of study. To improve the weighting it would be desirable to reduce to approximately 20 per cent the questions dealing with rules and to decrease to 10 per-cent those concerned with terminology. According to the curriculum set up the percentages on techniques and strategy are low and should be increased to approximately 47 per cent and 18 per cent respectively. A few questions on etiquette and equipment need to be added. To date, however, additional discriminating questions in these areas have not been developed.

ITEM VALIDITY

Table 1 indicates the number and per cent of the questions that discriminate at each level of confidence. On the total examination 95 (89.61%) items discriminate at a fairly high level (5% or better) with 87 (82%) discriminating at the 1-per-cent level.

TABLE 1

*Number and Percentage of Questions that Discriminate at the 5% Level of Significance or Better*

| Level | Number | Percentage |
|---|---|---|
| 1% | 87 | 82.07 |
| 2% | 4 | 3.77 |
| 3% | 1 | .94 |
| 5% | 3 | 2.83 |
| Total | 95 | 89.61 |

NOTE: Number of cases—343.

As the item validity ratings (see Appendix I) show, there are still some questions which either should be reworded or replaced. For this report they have been left in the examination to indicate to the reader the various knowledges that the committee wished to sample. To date the committee has been

unsuccessful in its attempt to cover these particular knowledges with satisfactory questions. Questions 7 and 22 with negative discriminations should be deleted or completely reworked. Questions 1, 4, 8, 9, 11, 18, 26, 77, and 82 are not as good as they might be since their phi coefficients are too low for confidence even at the 5-per-cent level. However, when these questions were studied on previous administrations of the examination, all but questions 1, 4, 7, 9, and 11 have discriminated at the 5-per-cent level or better. The difference in results on questions 8, 18, 26, 77, and 82 might be explained by the fact that different instructors teach beginning badminton during various quarters, and even though course content is standardized, some variation may exist in the stress that is placed on different phases of the material. Since these questions have been found to discriminate at a previous administration of the test, it is possible that the wording is satisfactory and the fault lies with the instructors' failure to follow the curriculum rather than with these examination questions.

ITEM DIFFICULTY

Appendix I shows the difficulty factor of each test item and the frequency distribution of the difficulty of the test items is shown in Table 2. With each revision of the examination, the number and per cent of easy questions was reduced. Of the 16 questions with a percentage difficulty below ten, all but three (questions 11, 18, and 82) discriminate at the 5-per-cent level or better and nine discriminate at the 1-per-cent level. Question 11 is adding little to the examination and should be deleted. Questions 18 and 82 are useful in pointing out the good and the poor students and are very close to discriminating at the 5-per-cent level.

TABLE 2

*Distribution of Item Difficulty*

| Difficulty | Number | Percentage |
|---|---|---|
| 0–9 | 16 | 15.09 |
| 10–19 | 38 | 35.84 |
| 20–29 | 21 | 19.81 |
| 30–39 | 16 | 15.09 |
| 40–49 | 9 | 8.49 |
| 50–59 | 3 | 2.83 |
| 60–69 | 3 | 2.83 |

NOTE: Number of cases—343.

## Summary

The badminton written examination is objective and seems to satisfy the requirements for a good test. It has been set up so that questions are uniformly arranged. A separate score sheet (Appendix IV) for ease of handling and correcting papers has been used. The examination can be completed in the regular class period, 50 minutes in length.

The reliability of the examination has been found to be .90 + .012 and .88 ± .008. The range of difficulty of the questions was from 2 to 69.67 per cent.

It is felt that curricular validity is satisfied to the extent that all of the material sampled by the test is taught in all of the beginning classes. The percentage of questions on techniques and strategy is slightly low, and that on rules and terminology slightly high, for complete agreement with the curricular emphasis.

Almost 90 per cent of the items discriminate at the 5-per-cent level or better. Eighty-two per cent of them discriminate at the 1-per-cent level. Only 1.8 percent (two questions) show a negative discrimination, and these should be dropped from the examination.

Since the scores made on the test by 343 students in beginning badminton classes ranged from five to 62 errors, the examination has proved to be useful in assigning knowledge grades to students in beginning badminton classes.

**Conclusions**

1. The examination has proved reliable.
2. The curricular validity would be improved if the poorer items on rules were replaced by items dealing with techniques and strategy.
3. The examination is useful in discriminating between the students who know the most about badminton and those who know the least following a course in beginning badminton.
4. Two questions (7 and 22) with a negative discrimination should be deleted or replaced.
5. The examination is useful for grading the knowledge of students in beginning badminton classes.

## APPENDIX I

PHI COEFFICIENTS, LEVEL OF SIGNIFICANCE, AND DIFFICULTY RATINGS OF QUESTIONS ON FINAL FORM OF BADMINTON WRITTEN EXAMINATION

(Number of cases—343)

| Question | Phi Coefficient | Level of Significance | Difficulty |
|---|---|---|---|
| 1 | .012 | | 23.61 |
| 2 | .286 | 1% | 15.45 |
| 3 | .283 | 1% | 12.53 |
| 4 | .084 | | 27.69 |
| 5 | .217 | 1% | 3.79 |
| 6 | .176 | 2% | 2.04 |
| 7 | −.025 | | 20.69 |
| 8 | .054 | | 29.44 |
| 9 | .067 | | 16.61 |
| 10 | .324 | 1% | 30.90 |
| 11 | .019 | | 8.74 |
| 12 | .334 | 1% | 20.69 |
| 13 | .320 | 1% | 9.91 |
| 14 | .208 | 1% | 12.82 |
| 15 | .147 | 5% | 22.15 |
| 16 | .319 | 1% | 18.95 |
| 17 | .197 | 1% | 4.95 |
| 18 | .133 | | 8.74 |
| 19 | .205 | 1% | 39.94 |
| 20 | .334 | 1% | 31.48 |
| 21 | .373 | 1% | 17.49 |
| 22 | −.011 | | 34.11 |
| 23 | .204 | 1% | 10.20 |
| 24 | .170 | 2% | 35.56 |
| 25 | .191 | 1% | 47.81 |
| 26 | .124 | | 15.45 |
| 27 | .416 | 1% | 17.20 |
| 28 | .278 | 1% | 13.11 |
| 29 | .315 | 1% | 16.32 |
| 30 | .433 | 1% | 26.53 |
| 31 | .241 | 1% | 3.20 |
| 32 | .227 | 1% | 11.66 |
| 33 | .168 | 2% | 3.79 |
| 34 | .275 | 1% | 19.82 |
| 35 | .240 | 1% | 51.02 |
| 36 | .253 | 1% | 33.52 |
| 37 | .410 | 1% | 47.52 |
| 38 | .454 | 1% | 32.94 |
| 39 | .404 | 1% | 19.82 |
| 40 | .454 | 1% | 41.39 |
| 41 | .382 | 1% | 15.45 |
| 42 | .250 | 1% | 13.41 |
| 43 | .351 | 1% | 30.02 |
| 44 | .183 | 1% | 6.12 |
| 45 | .143 | 5% | 1.16 |
| 46 | .215 | 1% | 17.49 |
| 47 | .319 | 1% | 22.44 |
| 48 | .142 | 5% | 6.99 |
| 49 | .467 | 1% | 62.97 |
| 50 | .262 | 1% | 11.95 |
| 51 | .174 | 2% | 22.44 |

APPENDIX I—*Continued*

| Question | Phi Coefficient | Level of Significance | Difficulty |
|---|---|---|---|
| 52 | .375 | 1% | 10.78 |
| 53 | .346 | 1% | 10.20 |
| 54 | .197 | 1% | 4.37 |
| 55 | .215 | 1% | 29.44 |
| 56 | .300 | 1% | 16.03 |
| 57 | .359 | 1% | 31.77 |
| 58 | .375 | 1% | 12.53 |
| 59 | .240 | 1% | 17.49 |
| 60 | .161 | 3% | 11.95 |
| 61 | .273 | 1% | 12.82 |
| 62 | .384 | 1% | 16.03 |
| 63 | .362 | 1% | 16.90 |
| 64 | .431 | 1% | 48.68 |
| 65 | .310 | 1% | 16.61 |
| 66 | .280 | 1% | 10.20 |
| 67 | .287 | 1% | 36.73 |
| 68 | .331 | 1% | 69.67 |
| 69 | .425 | 1% | 18.07 |
| 70 | .240 | 1% | 17.20 |
| 71 | .333 | 1% | 54.51 |
| 72 | .241 | 1% | 3.79 |
| 73 | .457 | 1% | 39.65 |
| 74 | .450 | 1% | 18.07 |
| 75 | .290 | 1% | 18.07 |
| 76 | .182 | 1% | 43.73 |
| 77 | .071 | | 57.43 |
| 78 | .400 | 1% | 41.69 |
| 79 | .432 | 1% | 25.94 |
| 80 | .258 | 1% | 7.58 |
| 81 | .370 | 1% | 20.99 |
| 82 | .126 | | 4.95 |
| 83 | .470 | 1% | 66.18 |
| 84 | .595 | 1% | 27.11 |
| 85 | .434 | 1% | 44.60 |
| 86 | .371 | 1% | 43.14 |
| 87 | .328 | 1% | 19.82 |
| 88 | .336 | 1% | 20.55 |
| 89 | .336 | 1% | 20.55 |
| 90 | .335 | 1% | 41.98 |
| 91 | .384 | 1% | 31.48 |
| 92 | .307 | 1% | 9.03 |
| 93 | .266 | 1% | 13.70 |
| 94 | .331 | 1% | 28.57 |
| 95 | .260 | 1% | 22.15 |
| 96 | .267 | 1% | 26.62 |
| 97 | .267 | 1% | 26.62 |
| 98 | .267 | 1% | 26.62 |
| 99 | .325 | 1% | 25.36 |
| 100 | .317 | 1% | 30.90 |
| 101 | .286 | 1% | 15.45 |
| 102 | .390 | 1% | 37.02 |
| 103 | .431 | 1% | 37.60 |
| 104 | .348 | 1% | 15.74 |
| 105 | .435 | 1% | 18.65 |
| 106 | .330 | 1% | 37.60 |

## APPENDIX II

PHI COEFFICIENT NECESSARY FOR LEVELS OF SIGNIFICANCE

| Level | Phi Coefficient |
|---|---|
| 1% | .182 |
| 2% | .164 |
| 3% | .153 |
| 5% | .138 |

## APPENDIX III

BEGINNING BADMINTON Test Number

Final Examination

ANSWER ALL QUESTIONS FOR A RIGHT-HANDED PLAYER.

Part I. *Multiple True-False:* If the statement is entirely correct, encircle the "T" on the score sheet. If the statement is totally or partially incorrect, encircle the "F" on the score sheet.

A. When using the Eastern forehand grip:

1. The top plate of the handle comes in the middle of the "V" made by the thumb and forefinger.
2. The thumb and forefinger exert the most pressure in maintaining the grip.
3. The racket face is parallel to the ground when the player grasps the racket.
4. The thumb curves around the handle of the racket.

B. In the SHORT serve:

5. The server squarely faces the net.
6. The shuttle flight is high over the net.
7. The weight of the body is slightly forward over the left foot.
8. The racket contacts the shuttle slightly ahead of the forward foot.
9. The follow-through of the racket is forward.

C. In the LONG serve:

10. The server attempts to make the backswing resemble the backswing of the short serve.
11. The weight is transferred from the back to the forward foot as the racket is swung forward.
12. The wrist leads the racket until just before the moment of impact of racket and shuttle.
13. The desired flight of the shuttle is low and flat over the net.

D. In the forehand UNDERHAND clear:

14. The weight, during the backswing, is on the forward foot.
15. The elbow is straight at the time the shuttle is hit.
16. The left side should be toward the net.
17. The shuttle is contacted below waist level.
18. The follow-through of the racket is in line with the shuttle path.

E. In the forehand OVERHEAD clear:

19. At the finish of the backswing, the elbow and wrist bend so that the racket head drops below the shoulders.
20. The shuttle is contacted slightly behind the head.
21. The elbow is bent at the time of impact of racket and shuttle.
22. As the racket swings to meet the shuttle, the body is turned so that the shoulders are parallel with the net.

F. In the forehand SMASH:

23. The backswing should resemble that of the overhead clear.
24. The shuttle is contacted at the height of the player's reach.
25. The shuttle is contacted at a point above the right foot.
26. Speed is imparted to the shuttle by snapping the wrist just before the moment of contact of racket and shuttle.

G. A "let" in badminton is:
   27. The re-playing of any rally when ordered by the umpire.
   28. The act of one side conceding a point.
   29. A served shuttle touching the net and landing in the correct service court.
   30. A shuttle during a rally touching the net and landing in the opponent's court.

H. In serving:
   31. The shuttle must be contacted below waist level.
   32. The server and receiver may take any position within the playing court boundaries.
   33. The server must keep some part of both feet in contact with the floor.
   34. The racket head may not be higher than the hand.

I. In doubles, if a player serves out of turn or from the wrong court:
   35. There is no penalty if the receiving side has won the rally.
   36. A "let" is called if the serving side has won the rally.
   37. Any time that the error is discovered, the players must take their correct positions.
   38. She loses her term of service.

Part II. *True-False:* If the statement is entirely correct, encircle the "T" on the score sheet. If the statement is totally or partially incorrect, encircle the "F" on the score sheet.

39. It is a fault if a player is struck by a shuttle, whether she is standing inside or outside the boundaries of the court.
40. It is illegal for a player to return the shuttle while she is standing outside the court.
41. It is legal for a player's racket to follow-through over the net.
42. A point is scored whenever a fault is committed.
43. The winner of a game must have at least two more points than the loser.
44. If the receiver hits into the net a served shuttle that would have fallen short, she may claim the serve a fault.
45. A player is deemed ready if she attempts to return a serve.
46. There is a penalty for touching the net just after the shuttle has gone into the net.
47. During the serve, when the receiver's foot is on a line, it is considered within her court.
48. It is a fault to strike the shuttle before it crosses to the striker's side of the net.
49. In doubles, all four players must be within the limits of their respective service courts until the serve is delivered.
50. If a team declines setting a game at 13 all, they may do it at 14 all.
51. If the partner of the receiver hits the served shuttle, a point is scored for the serving side.
52. In doubles, no person may receive two consecutive serves.
53. The partner of the server of the first "in" of a game gets a chance to serve the shuttle before the opponents serve.
54. When a doubles team becomes "in" the first serve is taken in the right court.
55. At the finish of the backswing for overhead shots, the elbow is lower than the shoulder.
56. To execute a good drive, a player should stand directly behind the oncoming shuttle.
57. The backswing of the forehand overhead clear should be the same as the backswing for the overhead drop.
58. To return a shot, the player should wait until the shuttle crosses the net and then move into position as quickly as possible.
59. In a net shot, the shuttle should pass close to the top of the net.
60. When playing singles, after each stroke, the player should attempt to return to the middle of the court.
61. A smash is effective when executed from the back of the court.

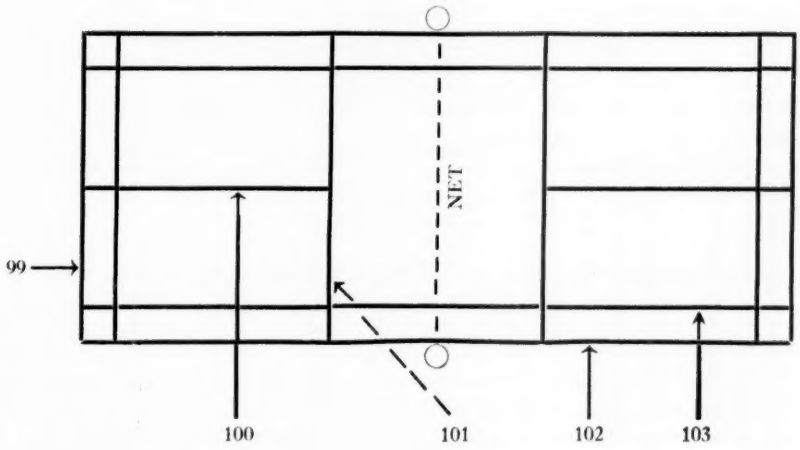
Part III. *Short Answer:* In the spaces provided on the score sheet, answer the following questions and complete the following statements in as few words as possible.

62. In announcing the score, whose score is given first? (62).
63. How does play continue when a player, while serving, swings at the shuttle and completely misses it? (63).
64. When is a serve considered to be delivered? (64).
65. In doubles, which team serves first at the beginning of the second game? (65).
66. In a singles game the server has an even score. From which court will she serve? (66).

67. When do partners on the "in" side change service courts? (67).
68. What is the score in women's singles when the game may be set to 3? (68).
69. What is the decision in the following situation? Both players on one side of the net touch the shuttle and it goes over the net within the playing boundaries of the opponents' court. (69).
70. What is the decision in the following situation? "A" serves a shuttle which would have gone out of bounds. Her opponent, "B", returns it. (70).
71. What happens if a player swings at a shuttle but misses it and the shuttle lands out of bounds? (71).
72. A shuttle falling on a line is (72).
73. The best two out of three games is called (73).
74. If only one 15-point game is played, players change sides of the net when one side has a score of (74).
75. When a game is played without an unpire, the score is announced by (75).
76. The score after a game has been "set" is (76).
77. If, during a rally, the shuttle after passing over the net is caught in the net it is (77).
78. An indistinct hit or sliding contact between the racket and shuttle is called (78).
79. Directing the shuttle to a specific spot on the court is called (79).
80. Any stroke used in returning a shuttle from the non-racket side of the body is called (80).
81. The name for an alert position assumed by a player when waiting for the shuttle to be hit by an opponent is (81).
82. A four-handed game is called (82).
83. During the rally, a shot from the player's right court to the opponent's right court is called (83).
84. An intermediate attacking stroke between an overhead and underhand shot is (84).
85. A player gains the offensive when she has forced her opponent to direct the flight of the shuttle (85).
86. When a shuttle is hit from a height and falls almost perpendicularly, just over the net, the stroke is called (86).
87. A good stroke to use to give a player time to get back into position is (87).
88. A long service, in singles, to be effective should be (88).
89. and (89).
90. In doubles, the person playing net should stand near the (90).
91. In doubles, when the serve changes from one partner to another, it is called (91).
92. The type of doubles play in which each player is responsible for covering one half of the court from the net to the back service line is called (92).
93. The playing formation usually used in mixed doubles is the (93).
94. In singles, after having been forced deep in the court to return a shuttle, the player should attempt to move to (94).
95. The serve used most frequently in singles is the (95).
96. In covering court, three acceptable ways of using the feet are (96),
97. (97),
98. and (98).

Part IV. *Identification:*

A. Give the official names of the lines of the court that are numbered in the diagram placing the name in the blank provided on the score sheet.




B. On the A side of the diagram on the score sheet shade in:
104. The right singles service court.
105. The left doubles service court.
C. 106. On the B side of the diagram on the score sheet shade in the doubles playing area.

(*See next page for Appendix IV*)

## APPENDIX IV

PHYSICAL EDUCATION 118 (BEGINNING BADMINTON)

SCORE SHEET

Name_____ Section_____ Test No._____ Date_____

*Part I*

1. T F
2. T F
3. T F
4. T F
5. T F
6. T F
7. T F
8. T F
9. T F
10. T F
11. T F
12. T F
13. T F
14. T F
15. T F
16. T F
17. T F
18. T F
19. T F
20. T F
21. T F
22. T F
23. T F
24. T F
25. T F
26. T F
27. T F
28. T F
29. T F
30. T F
31. T F

*Part II*

32. T F
33. T F
34. T F
35. T F
36. T F
37. T F
38. T F
39. T F
40. T F
41. T F
42. T F
43. T F
44. T F
45. T F
46. T F
47. T F
48. T F
49. T F
50. T F
51. T F
52. T F
53. T F
54. T F
55. T F
56. T F
57. T F
58. T F
59. T F
60. T F
61. T F

*Part III*

62._____
63._____
64._____
65._____
66._____
67._____
68._____
69._____
70._____
71._____
72._____
73._____
74._____
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77._____
78._____
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92._____
93._____
94._____
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96._____
97._____
98._____
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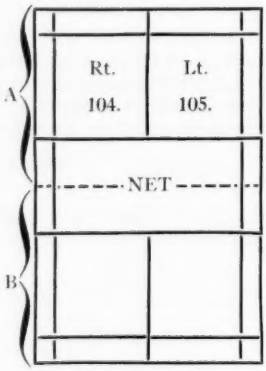
100._____
101._____
102._____
103._____




106.

# The Court Ball Game of the Aboriginal Mayas[1]

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THE SPORTS AND recreational pursuits of aboriginal and modern primitive peoples have always been of deep interest to those concerned with physical education or its related fields. Unfortunately, physical educators have done relatively little research in this area and the studies that have been made are usually by men trained in one of the branches of anthropology. While this has resulted in some excellent studies, the results have not always been adapted to the physical education viewpoint. As a consequence the full benefits of many of these investigations have escaped us. The possibilities for research in the fields of archaeology, ethnology, and cultural anthropology stressing the physical education viewpoint were pointed out in an article by Stumpf and Cozens (33).

To have a complete understanding of the culture of any peoples, aboriginal or modern, it is necessary to have an adequate appreciation of the role played by their games, sports, and recreational amusements. Of the three great native civilizations of the New World, the Aztec, Inca, and Maya, the most enduring was that of the Mayas. An integral part of this brilliant civilization which lasted for 1100 years was the court ball game originated by them. Its mythological origin and religious significance is inextricably bound with the rise and fall of their nation. Many existing codices, manuscripts, and written accounts of both the pre-and post-Conquest era attested its importance as part of the Maya culture.

### Purpose of the Study

The expressed purposes of this study are: (1) A determination of the origin, development and diffusion of the court ball game in ancient Middle America; (2) The specific rules, techniques and equipment used plus the construction of the ball courts; (3) The cultural importance of the ball game to the Mayas and the tribes who subsequently played it.

### Review of the Literature

Studies relating to the role of games, sports, and recreational amusements of modern primitive peoples have been made by Stumpf and Cozens on the New Zealand Maoris and the Fiijians (34). A similar study was completed by Dunlap (12) with respect to the Samoans. Many archaeologists and travelers

[1] This study was made while the author was a graduate student in the School of Health, Physical Education, and Recreation at Indiana University.

have written on some phase of the ball court sites but the work of Maudsley (1) is particularly valuable. A thorough investigation was submitted by Blom (3) in the Middle America Research Series. Both of these reports are the work of renowned archaeologists and have stressed that aspect in their writings. With the exception of these studies, all others may be classified as more or less descriptive references of the actual ruins of ball court sites or brief mention of such a game having formerly been played by the Mayas and Aztecs.

**Procedure**

The basis of the study rests upon two visits made by the author to Mexico, Yucatan, and Guatemala. During the course of these trips several visits were made to the ball courts at Chichen Itza and Uxmal in the northern section of the Peninsula of Yucatan, and the court site of Monte Alban in the State of Oaxaca. Black and white and kodachrome still pictures were taken by means of an Argus C-3 camera. A Ciné Kodak 8 mm. camera was used for motion pictures. Tape measurements and compass directions of the court layout supplemented the above.

In addition to this work in the field, extensive use was made of the archaeological collections of the museums in Mexico City, Oaxaca, Merida, and Guatemala City. Miniature scale models of the main ball court at Chichen Itza were available for study in the Chicago Field Museum of Natural History as well as the museum in Merida.

A critical review was undertaken of the works of 16th century writers who dealt with the period of the Spanish Conquest and the history and culture of the Indians of Middle America. The John G. White Collection of Folklore and Orientalia of the Cleveland Public Library was particularly helpful in making available authentic facsimiles of codices and manuscripts which were impossible to secure otherwise.

**Geographic Locale and History**

The geographic region of the aboriginal Mayas consisted of the present day states of Yucatan, Campeche, Tabasco, Quintana Roo and the eastern half of Chiapas in the Republic of Mexico. These with the southern highlands and Department of Peten in Guatemala, all of British Honduras, and the adjacent western part of the Republic of Honduras combined to form an area of approximately 150,000 square miles.

The term "Mayan civilization" is defined by Morley (22) as applying exclusively to that ancient American culture which had as its two principal material manifestations unique hieroglyphic writing and chronology and, so far as North America is concerned, a unique stone architecture involving the use of corbel-stone roof vaults. Wherever these two cultural traits existed in Middle America—that is southern Mexico and Northern Central America—the Mayan civilization may be considered as having existed.

The birthplace of the Mayan civilization is believed to have originated in the climatically favorable north central section of the Department of Peten, Guatemala in the 4th century A.D. Two great periods of development followed. The first and greatest was the Old Empire era, which began in 317 A.D. and

reached its zenith in the 8th century. From this time on, the old Empire deteriorated rapidly until by the year 987 the large cities were deserted and the era was completed.

The New Empire era began in the 10th century with a spectacular period of renaissance which was confined to northern Yucatan and was fostered by the arrival of Toltec tribes from central Mexico who modified the existing Maya culture. A period of initial growth reached its culmination in the 13th century to be followed by cultural corruption and decay so that the New Empire was dying when the Spaniards first arrived in Yucatan in 1527. The last independent Mayan political entity existed on an island in Lake Peten Itza, Guatemala, and was brought under Spanish domination in the year 1697.

This brilliant native civilization developed independently of outside influence as the result of favorable climatic and geographical conditions coupled with the native genius of the Mayas. The eventual cause of its decay is still a matter of debate. One theory is that, since it was a maize-culture civilization, the peculiar milpa method of agriculture depleted the soil to such an extent that the civilization could no longer exist (10, 11). The Mayas made great progress in the arts and sciences. Independently they developed a system of hieroglyphic writing and a positional arithmetic with the concept of zero. The calendar employed by them at the time of their first meeting with the Spaniards was more exact than that in use at the time in Europe.

### The People

Today almost two million people live in the area once occupied by the ancient Mayas.

The present-day Maya is physically of small stature, the average height for men is 5 feet 1 inch and 4 feet 8 inches for women. The physique is very broad-shouldered and deep-chested, with comparatively long hands and feet. The cephalic indexes of 85.8 for the men and 86.4 for women make them one of the broadest-headed people in the world (31). Black, straight, and rather coarse hair is combined with a skin color of a coppery brown which may vary slightly with the individual. Body hair is relatively scarce. An Asiatic origin is strongly suggested by the epicanthic eye fold, the so-called "Mongolian spot" at the base of the spine, and the line patterns of the palms of the hands (22).

The modern-day Maya may be described as an active, energetic, and hard-working individual. There is little desire for supremacy and a marked spirit of conservatism which makes them cling to their ancient customs and beliefs.

## THE BALL GAME

### Origin, Name, Diffusion

The origin of the court ball game has been a question of debate among Middle American archaeologists ever since the discovery of ball court sites. These may be divided into three main groups depending upon their belief. The first group hold that the ball game was originated by the ancient Mayas; the second group holds a similar viewpoint for the Toltecs of central Mexico; the third group holds out for an origin different from the two above. Broadly

speaking, the Toltec may be considered as the forerunners of the Aztecs who subsequently occupied the same region.

The earliest reference to the ball game is to be found in the Popol Vuh (5, 16, 30). This book was held sacred by the Quiche Mayas of the Guatemalan highlands. In Part II of this book, reference is made to two divine heroes, the brothers Hunhun-Ahpu and Vukub-Hunahpu, who were fond of playing the ball game. One of these games was played near Xibalba, the underworld and place of the dead. The monarchs of this region became annoyed at the ball game in progress and challenged the intruders to a game with the intent of defeating and disgracing them. The brothers accepted the challenge but were betrayed by the Lords of the Underworld and put to death. Other references to the ball game are to be found in the Popol Vuh following this initial mention. From this earliest of references it is seen that the ball game is considered to have been of divine origin.

The Popol Vuh is estimated to have been written around the year 700 A.D. The above account far precedes that from any other known source and dates the ball game as having been played by the Mayas at least 200 years prior to any other reference to it by a source outside of the Maya area.

Gann (14) was of the opinion that the ball game was introduced to the Mayas by the Toltecs about 1200 A. D. However, this statement was made when very few ball court sites had been discovered in the Maya area. Subsequently, many more courts were uncovered by various archaeological expeditions. The Toltec theory of origin is also supported by Vaillant (37) who states that game was introduced by Topiltzin, the 9th king of the Classical Toltecs. Since accurate accounts of the dynasties of the Toltec rulers are available, this would have been around the year 900 A.D. which still falls 200 years after the first Mayan reference, cited in the Popol Vuh.

Thompson (35) has postulated a possible South American origin for the game but has given no details as to how he arrived at this opinion. Most bizarre of all the theories of origin is that advanced by Mitchell (21). A study of various related parallels in the Popol Vuh as compared with ancient Egyptians has convinced him that the ball game is of Egyptian origin. He supports this opinion by pointing out that in Part II of the Popol Vuh there is a description of recovering the head of Hun-Ahpu, one of the sons who was treacherously slain by the Lords of the Underworld during a game of ball. This incidence is taken by him to be a symbolic representation of the fight for, and the recovery of, the body of Osiris in Egyptian mythology. In later years the recovery of the actual body was dispensed with and the symbol of the head used instead. However, since this theory is based solely on the religious significance of certain parallel rites and is unsupported by any other evidence as to just how the Egyptian game arrived in Middle America it is scarcely held tenable and is cited for its curiosity value.

Archaeological expeditions of the Carnegie Institute of Washington, the Peabody Museum of Harvard University, and those of other foundations and universities, have discovered more than 40 ball court sites of which more than three-quarters have been located in the area formerly inhabited by the Mayas. Two of the foremost Middle American archaeologists of the present day, Blom

and Morley, held that the weight of evidence is now distinctly in favor of attributing the origin of the ball game to the Mayas.

That the game was widely diffused is indicated by the presence of ball court sites from Guatemala and Honduras as far north as south-eastern Arizona (37). At the time of the first visit of the Spaniards to the Aztec capital of Tenochtitlan, the present Mexico City, a ball court was situated in the main plaza of the city (29).

In numerous Aztec codices there are representations of the gods playing in a ball court. The Codex Colombino (8) has an excellent illustration of the Lord of the Day and the Lord of the Night who are depicted as ready to play a game. A doubles game in progress is shown in the Codex Borbonicus. The gods Xochipilli and Ixtilton are playing as partners against the gods Quetzalcoatl and Caoutlicue (7).

Granting the Maya theory of origin as being the correct one, it seems probable that the ball game was taken up by the Toltecs who eventually passed it on to the Aztecs with whom it found great favor. The Aztecs in turn introduced the game to those tribes subjugated by them so that eventually the ball game had spread from Guatemala to the northern end of Mexico.

In an effort to trace the name used in describing the ball game it is necessary to go to the native language dictionaries compiled by the early Spanish friars. These vocabularies are of great aid in tracing words and word derivations referring to the game.

The ball game was called "Pok-ta-pok" by Mayas and "Tlachtli" by the Aztecs. In the Pio Perez dictionary of the Maya language, the following words refer to the game (28):

*Pok:* The stroke that throws the ball.
*Pokolpoktah:* To play ball.
*Pokolpoc:* The ball game and how to play it.

The Aztec name of "Tlachtli" is probably a derivation from the language of the Zapotecs who live in the southern part of Mexico. Hernandez (17) states that the Zapotec word 'lachi' meant, "pelota de los Indios" which translates as "ball game of the Indians." He also designates the word "tlachtlilachi" as meaning "jugar pelota" or, "to play ball" (17).

Torquemada (36) refers to the ball court as being called "tlacho" by the Aztecs and on several pages of the Codex Mendoza the word "tlacho" is shown as the name glyph for a town named Tlacho (9). The glyph of this town consists of the characteristic *I*-shaped character patterned on the actual ground shape of the ball courts.

A certain passage in the Popol Vuh refers to a country described as being that of, "the ball playing and fisher people." Probably this refers to the tribe later known as the Olmeca who inhabited a section of Mexico that bordered on the western part of the ancient Maya domain. The name meant "rubber people" and refers to the fact that rubber trees grew in their locale and they were familiar with its use. Approximately this same area is mentioned in the Codex Mendoza as being the site of 22 towns that paid an annual tribute of 16,000 rubber balls to the Aztec sovereign.

The Popol Vuh reference to the Olmeca as being the "ball playing and fisher people" is further substantiated by the following word derivations of the Nahua language in central Mexico (25).

*Ollama:* To play ball with the buttocks.
*Ollamani:* A player of the ball game.
*Ollamia:* To play the ball game with other people.

**Popularity of the Game**

Numerous writers who were eye witnesses of the Spanish conquest of Mexico, Yucatan, and Guatemala have left descriptions or references to the native game as played by both the Mayas in Yucatan and the Aztecs in Mexico. Thus, Herrera (18) writes of Montezuma II, the Aztec emperor at the time of the conquest by Cortes:

> "The King took much delight in seeing sport at ball, which the Spaniards have since prohibited, because of the mischief that often happened at, and was called by them Tlachtli, being like our tennis."

The banning of the ball game by the Spaniards was undoubtedly at the instigation of the clergy who wished to discourage the pagan beliefs and ceremonies which accompanied the ball games. These would have been continued by permitting the Indians to engage in their game. In fact, such was the appeal of this rugged sport that it was beginning to be played by the Spaniards themselves until the prohibition against playing it went into effect.

Each town of that time had its ball court, more or less elaborate according to the wealth and prestige of the town:

> ". . . It should be understood that in all the cities and towns which had some reknown and standing and serious authority, as well among the citizens as among the rulers (of which they made much) and in order not to be inferior, one to the other, they built ball courts enclosed with fine walls, and well ornamented, with the whole inside smooth and covered with mortar, with many paintings of effigies and idols and devils to whom the game was dedicated and whom the players had for protectors in that sport." (13)

The popularity of the sport is shown by the fact that the kings and nobles played it. The Aztec emperor is described by Clavijero as being a participant (6).

> "This game was in high esteem with the Mexicans, and in other nations of that kingdom, . . . The kings themselves played and challenged each other at this game; as Montezuma II did Nezahuapilli."

The game cited above was played to settle a difference of opinion in regard to the interpretation of certain omens. It was a common practice of that time for the people to play a game of ball in order to settle disputes.

**The Ball Used**

The ball used was one of solid rubber as may be judged from the accounts of Ovieda, Duran, and Herrera: The former describes the ball quite clearly (26).

"The balls are made out of the roots of trees and herbs and juices and mixture of wax and pitch. Bringing together these and other materials they boil it all and make a paste, then they gave it a round shape and make the ball the same size as those filled with air in Spain, and some they make larger and some smaller; the mixture has a black, shiny surface and does not stick to the hand. After it is dry it becomes somewhat spongy, and not because it has any holes or vacuum as sponges have, but it becomes light and soft and quite heavy. Without comparison these balls jump more than those filled with air because by simply dropping it from your hands on the ground it jumps much higher in the air and gives a jump, another, one more and another, and as many more, the jumps becoming smaller every time."

"The ball is—as some people may have seen—as large as a small ball used in playing nine-pins. The material of which the ball is made is called Olin, which I have heard to be called Batel in our Spanish which is the rosin of a special tree which when boiled becomes like sinews. It is plentiful and is used by the natives both as medicine and as offering. It has one property which is that it jumps and rebounds upwards, and continues jumping from here to there so that those who run after it become tired before they catch it." (13)

The reference to Batel is probably in connection with the native ball game encountered by the early Spaniards on the islands of Cuba and Haiti. This game was called Batey or Batel by the natives of those islands.

"The ball was made of the gum of a tree that grows in the hot country, which, having holes in it, distils great white drops, that soon harden, and being worked and molded together turn as black as pitch. The balls made thereof, tho' hard and heavy to the hand, did bound and fly as well as our footballs, there being no need to blow them . . ." (18)

The early Spaniards were among the first of the New World explorers to come into contact with rubber. They called this substance "caoutchouac" and were amazed by its peculiar physical properties. It has already been pointed out that the number of rubber balls paid in annual tribute to the crown of Mexico shows that large numbers were manufactured at that time. These balls varied in size and there is no evidence of any type of standardization in this respect. The size was partly determined by such factors as the diameter of the hole in the stone ring, size of the playing court, and it would be reasonable to assume that lighter and smaller balls would be made for the use of children and immature players.

**The Ball Courts**

Supplementing the written information derived from existing codices and the original accounts of the early Spaniards are the archaeological remains of several dozen ball courts. These edifices vary greatly in size and state of preservation. With the single exception of the court described by Vaillant as being in southeastern Arizona, the remainder are all situated in the Mayan-Mexican area of Middle America and Mexico. The largest and best preserved of these ball courts is the main court of Chichen Itza in Yucatan. It was rediscovered by Stephens after its existence had been forgotten to all but a few natives for almost three hundred years. His description of this court as he actually found it is important (32).

"It consisted of two immense parallel walls, each two hundred and seventy four feet long, thirty feet thick, and one hundred and twenty feet apart. One hundred

feet from the northern extremity, facing the open space between the walls, stands on an elevation a building thirty five feet long, containing a single chamber, with the front fallen, and, rising among the rubbish, the remains of two columns, elaborately ornamented with sculpture; . . ."

"In the center of the great stone walls, exactly opposite each other, and at a height of twenty feet from the ground, are two massive stone rings, four feet in diameter, and one foot one inch thick; the diameter of the hole is one foot seven inches . . ."

"These walls . . . we considered identical in their uses and purposes with the parallel structures supporting the rings at Uxmal, of which I have already expressed the opinion that they were intended for the celebration of some public games. . . . At Chichen Itza all the principal buildings have names; . . . and there is historical authority which, in my opinion, shows clearly the object and uses of this extraordinary structure, I shall call it, as occasion requires, the Gymnasium of Tennis-Court."

Since the main ball court at Chichen Itza is the largest and most elaborate of all the courts rediscovered, it will be described in detail. As seen from the air the court has the general shape of the capital letter *I* or of two capital *T*'s placed base to base. The most accurate measurements available are those of Maudsley (1) which are cited here.

The two parallel walls that form the sides of the court are each 272 feet long and placed 119 feet apart. These walls are 39 feet thick at their bases and taper to a top width of 16 feet 3 inches. The angle of slope of this backwall is 52 degrees. The inner side of the parallel walls are vertical and faced throughout with neatly-cut square blocks of stone. The height to the top of the walls from the playing surface of the court measures 27 feet. A terrace 5 feet 3 inches above the playing surface projects 10 feet outward from the inner side of each wall to end in a stone clad face which slopes toward the playing field. These sloping stone faces have 8 panels containing 84 figures carved in bas-relief. The terrace continues as a broad platform beyond the ends of each wall. The vertical face of the main walls rise 22 feet from the top of these terraces.

The two stone rings placed in the walls are 4 feet in diameter, 11 inches thick, with the diameter of the center hole being 19 inches. These rings are situated not in the exact center of the parallel walls as so many writers indicate, but are 134 feet from the south end of the walls and directly opposite each other. The center of the hole is 20 feet above the top of the terrace and 25 feet 3 inches above the ground level of the court.

Surmounting the southern end of the east wall is a restored temple named, "The Temple of the Jaguars" because numerous paintings of that animal are found on the walls of the temple room. A stairway with exceedingly steep risers leads up the back slope of the wall to side of the temple. The temple has a short flight of steps leading to the entrance which is flanked by two enormous feathered serpent columns.

On the top of the west wall are the remains of 3 small structures each of which consist of 2 parallel walls perpendicular on the inner side, but thicker at the top than the bottom, so that each wall has the appearance of leaning outward. The passage through these walls had apparently been roofed over and would have afforded sitting room for one person. Two of these similar corresponding structures are found directly opposite on the east wall. How-

ever, the site corresponding to the third such structure on the south end of the wall is occupied by the temple cited above. From their position at the boundaries of the court enabling the end spaces to be clearly observed and also directly above the rings Maudsley has concluded that they were used for umpire seats (1).

Approximately 100 feet beyond the ends of the parallel walls the playing field broadens out into the enlarged part of the *I* and this limitation is marked by end walls about 6 feet high with their extreme ends bent back at right angles to form a discontinuous part of the side walls of the ball court. A restored two-column temple is situated in the middle of the north wall and facing it from its position on the end wall of the south end of the court is another temple which is not, however, situated directly in the center of the end wall. Consequently there is a discrepancy in the symmetry of this end of the ball court.

The inside length of the playing field is 482 feet, by 119 feet in width between the parallel walls. The corresponding outside measurements are 545 feet and 225 feet respectively. The widths between the walls at the northern and southern end court areas are 222 feet and 208 feet respectively.

The massive stone rings are held in place by stone tenons which are firmly embedded in the stone blocks of the walls. The weight of these rings is considerable and reflects a high degree of engineering skill in placing them with such exactitude. Both rings were found in place by Stephens in his first visit to Chichen Itza although the court was several hundred years old at that time. Later on, the stone ring in the west wall was dug out by treasure seekers but was replaced when the court was restored by a archaeological party. Both rings are carved in bas-relief with a feathered serpent intertwining around the center hole.

The diagrams of the ground plan and cross sectional views of the court in Figure I will make the explanation clearer. The two parallel walls of the court are indicated by *A* with the stone terrace at the inner base designated as *B*. This stone terrace leads out to the sloping surface *C* which ends on the playing surface of the court *D*. The stone rings are shown by *E* and the sloping rear wall by *F*. The broadened ends of the playing field are marked *G* and both end walls indicated by *H*. The Temple of Jaguars surmounts the east wall as *I* with the two end wall temples marked as *J*. Remains of the possible umpires seats on both walls are labelled *K*.

There are no fewer than seven ball courts known at Chichen Itza. Of these six were in actual use when the city was last occupied by the Mayas and a seventh one, of earlier construction, lies buried under a later terrace located behind the Nunnery. In contrast to the large size of the main court detailed here is that of the smallest court in the same city. This court measures 65 feet in length and is 20 feet wide. It is situated behind the structure known as the Red House.

From the presence of certain characteristics archaeologists have concluded that the main court is neither pure Mayan or Toltec design but shows an intermingling of the characteristics of both cultures. While there are several indications of this Toltec influence the mere presence of feathered serpent columns

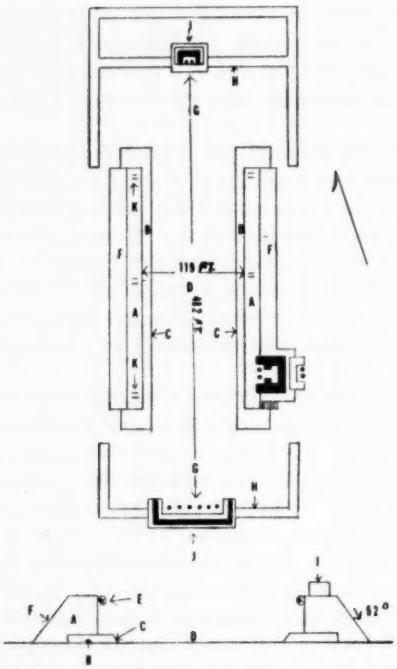


Fig. I. Main Ball Court at Chichen Itza, Yucatan. Cross Sectional View.

in the ball court temple serves as one of the easiest signs of such influence in the construction of the court.

The ruins of the ball court located at Uxmal show it to have been much smaller and less elaborate than the main court at Chichen Itza. The two parallel walls of the Uxmal court are situated 69 feet apart and are 155 feet long. The authors' measurements conflict with those of Gann who gave the same measurements as being 70 feet and 128 feet respectively. However, at the time that Gann took his measurements in the early 1920's, the ruins were incompletely excavated and the work done since that date in uncovering the court may account for the discrepancy in measurements. The two stone rings are still held *in situ* by means of the usual tenon. The outer portion of these rings has broken away but enough of each ring remains to determine the outside diameter of each as having been 4 feet. Sculptured on the north side of each ring is a band of hieroglyphics which date the erection of the ball court as having taken place in 1277 A.D. (14).

The walls of the court are in a poor state of preservation and so much debris has gathered under the stone rings that it is impossible to determine their exact height from the original playing surface of the court. This court did not have gallery space for the populace on top of the walls but was so constructed that it was possible to watch the game in progress by standing on two nearby

edifices known as the Nuns' Quadrangle and the House of the Governor. Since the ball game was played over many centuries of time, some modification of the playing court gradually evolved. These points of resemblance and modifications have been noted by Blom as follows (3).

> 1. All ball courts have the characteristic *I* shape in their ground plan.
> 2. The inner surface of the side walls are always smoothly surfaced and usually slope toward the playing court. These side walls are vertical only in the case of some ball courts in the north. In this respect the author would point out that the restored court at Monte Alban, Oaxac which would certainly be considered in the northern area, has sloping side walls. However, this case may be considered an exception to the general role.
> 3. The low terrace at the base of the playing walls is present in all courts.
> 4. The stone clad slope which leads from the terrace to the playing level of the court is found in the courts of all areas.
> 5. Stone rings are found only in the northern area courts or those courts which have been subjected to northern (Toltec) influence. Thus Joyce (19) feels that the Chichen Itza court displays the essential northern characteristics.

Descriptions of the ball courts have come down to us from many authentic sources. Sahagun records in his work (29):

> "The ball courts were one hundred, one hundred and fifty, and also two hundred feet long between where they ended in said corners. . . . In the center of this enclosure were placed two stone rings in the walls one opposite the other; these two (stones) had a hole in the center, which hole was encircled by an idol representing the god of the game. . . ."

A somewhat more detailed account is rendered by Duran (13):

> "They built ball courts enclosed with fine walls, and well ornamented, with the whole floor inside very smooth and carved with mortar. . . . These ball courts were better in some places than others and built after the plan shown in the picture, narrow at the center, and at the ends, broad with corners made purposely so that if the ball entered there the player would be at a disadvantage and lose the point. . . . The walls measured 1½ estados in height (10 to 12 feet) all around. . . . On the walls were either towers or effigies of stone placed at intervals. . . ."

It is a curious fact that archaeological excavations have discovered many stone rings in the northern area of the game but few actual court sites. In several of the towns of the Valley of Mexico, stone rings which were once used in the ball game have been erected in the town plaza. Such rings were formerly found in Coyocan and Texcoco.

The reverse is true of the southern area where many court sites have been uncovered but few, if any, stone rings. This was a puzzling fact to archaeologists for a long time until they reached the conclusion that the rings used in the game in the southern areas must have been made of wood or some other light material which would make them portable. This conclusion was justified when careful translations of the Popol Vuh indicated that in those passages referring to the ball game the rings are always written about in such manner that they must have been portable. Granting this explanation, coupled with the climatic assaults of many centuries, it is readily apparent that the portable

rings would disappear whereas the stone ones would remain. Blom (3) believes that the use of stone rings represented an advanced stage in the evolution of the ball game.

In general the northern area of the ball game has been considered as that part of the Republic of Mexico north of the Peninsula of Yucatan. The northern section of Yucatan is considered an intermediate area in which the influence of both the Mayas and Mexicans was brought to bear. All areas of the ancient Maya domain south of this northern portion of Yucatan are considered to be in the southern area.

The actual size of the stone rings varied a good deal. The measurements of eight stone rings in the collection of the National Museum in Mexico City are shown in table 1 (3).

TABLE I

*Comparison of Measurements Made of Stone Rings in the National Museum of Mexico City*

| | Diameter of Stone Rings | Diameter of Center Hole |
|---|---|---|
| Smallest | 32 cm. | 8 cm. |
| Largest | 102 cm. | 21 cm. |
| Range | 32 to 102 cm. | 8 to 31 cm. |

There was no standardization of court size, as is apparent from the diverse measurements made of existing sites. Ball courts have been located in Chiapas, Oaxaca, the Valley of Mexico, Yucatan, Quintana Roo, Guatemala, British Honduras, and Honduras. Of a total number of 40 known sites, more than three-quarters have been located in the southern area and the measurements of these have shown as wide a variation as the courts in the northern area.

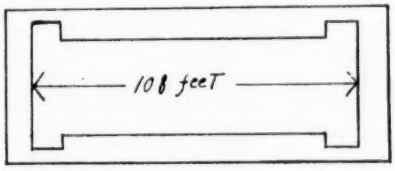
No doubt the larger courts were meant for team games with the smaller ones lending themselves to games of a singles or doubles nature. The possibility must not be overlooked that some of these smaller courts may have been constructed on a reduced scale to afford playing opportunity to the children of that time.

The placement height of the stone rings also varied from court to court. While the stone rings at Chichen Itza are placed a full 25 feet from the center of the ring to the playing surface, those at Uxmal, which are the same size, were estimated to have been placed only about 7 to 8 feet from the ground level of the court. Here again it is possible that the lower placement would lend itself well to the lesser skill and stamina of immature players. However, the reason for the variations in court size and ring height is not explained by any past writer so that we must fall back upon conjecture for an explanation

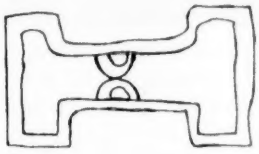
The direction of placement of the long axis of the court was not related to the cardinal points of the compass. Some of the early writers felt, owing to the religious significance of the game, that this matter of placement was important but the measurements of directions on the known court sites have varied as widely as in their respective sizes.

A study of the glyphs and depictions of the ball courts as found in codices

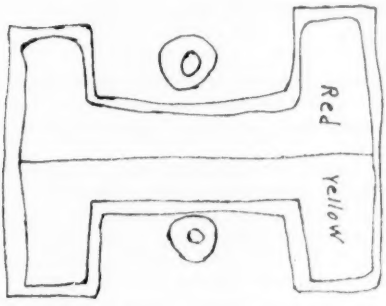
shows that the floors of those courts with surfaced areas were frequently painted different colors in various sections of the court (7). Thus, the court might have each of its four sections painted a different color, or it may have been divided into two halves, either along the long axis of the court or from ring to ring, and each half painted a different color. No particular significance has been discovered in the sequence of colors or sections painted. Illustrations in the Codex Colombino (8) show one court painted in four quarters, with the upper left red, upper right green, lower left quarter yellow, and the lower right quarter brown. Another is shown in the same sequence as yellow, green, brown, red and still a third as brown, yellow, red, and blue.




Ground Plan of the Ball Court at Rabinal from Maudsley.



Ball Court Glyph Codex Mendoza.




Ball Court Glyph Codex Borbonicus.

Fig. II.

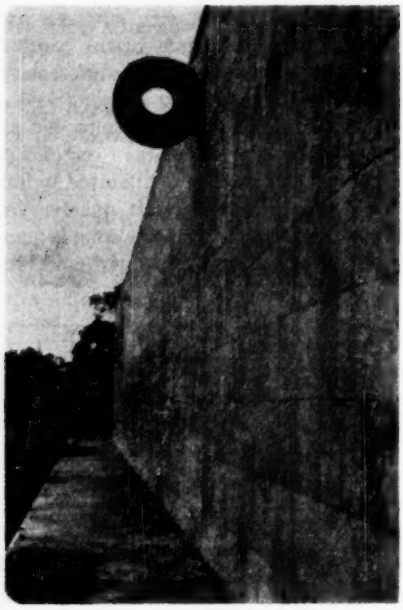


Fig. III. Stone ring in Position in East Wall of the Main Ball Court at Chichen Itza, Yucatan.

**Rules of Play**

The ball game was played under a definite set of stringent rules, for all early Spanish writers mention that it was considered illegal to strike the ball with the hands or feet. All are agreed on this one point of play. Prominent mention is also made of the type of protective gear worn by the players during the course of the contest.

> "All those who entered the game, played with leather placed over their loinclouts and they always wore some trousers of deerskin to protect the thighs which they all the time were scraping along the ground. They wore gloves in order not to hurt their hands, . . ."
>
> "Some were so outstanding in the game and made so many elegant moves in it that it was worth seeing and I will specially relate one which I saw done by Indians who had practiced it, and it was that they used a curious thrust or hit, when seeing the ball in the air, at the same time it was coming to the ground. They were so quick in that moment to hit it with their knees or seats that they hit the ball with extraordinary velocity. With these thrusts they suffered great damage on the knees or on the thighs, with the result that those who for smartness often used them, got their haunches so mangled that they had those places cut with a small knife and extracted blood which the blows of the ball had gathered." (13)

Since the ball might be up to almost a foot in diameter and was made of pure rubber and was driven by the full force of a skilled player, it is easy to imagine that considerable damage would have resulted to any player who was

unexpectedly struck by the ball. Along similar lines it is only necessary to recall some of the crippling and serious injuries which have resulted in modern playing of the Basque game of Jai-lai which in some respects is very similar to the ancient Mayan ball game.

Further evidence of the equipment worn by the players is given by the description taken from Sahagun's description (29):

> ". . . they did not play with their hands, but instead struck the ball with their buttocks; for playing they wore gloves on their hands and a belt of leather on their buttocks, with which to strike the ball."

A difference of opinion seems to have existed among certain writers as to what was considered legal and illegal in striking the ball. Some historians, like Sahagun, indicated that it was proper to use only the hips or the buttocks. A survey of the accounts of several early authors with respect to this point shows that the knees, thighs, hips, and buttocks were used for hitting the ball. There apparently was restriction in chesting and heading the ball, as in our modern-day soccer. Ovieda (26) is quite definite on this point:

> "They were so clever both those of the one side and those of the other in not allowing the ball to stop it was marvelous—for if to see those of our country (Spain) play ball with their hands gives us such pleasure and surprise, then seeing skill and speed with which some of them play, how much more must one praise those with such skill and dexterity and elegance play it with the buttocks and with the knees counting it a foul to touch the ball with any other part of the body except the two said parts, the buttocks and the knees."

There was general agreement on the wearing of leather hip and loin protectors by the players. In some of the drawings in the manuscripts and codices, the players appear to be wearing head protectors and gloves are mentioned as being worn in the accounts found in the Popol Vuh. No specific regulation on the uniform that could be worn seems to have existed. The players are sometimes depicted as wearing only a loin cloth and hip protectors and in other cases as fully clothed. A statuette of a ball player known as "Ollamani" in the National Museum of Mexico City shows the player to be wearing the loin cloth and hip protectors. Considering the activity involved in playing the game, it is probable that the players stripped down to a minimum in order to facilitate their play.

We are far less fortunate regarding more detailed rules of the actual playing than in the accounts dealing with equipment. It is certain that the object of the game was to score a goal by hitting the ball in a fair manner through the fixed ring. In the case of a goal being scored, the player scoring it had the right to the cloaks of all the spectators who immediately left the scene in an endeavor to save their apparel.

> ". . . and he that could strike it through won the game; and in token of it being an extraordinary success, which rarely happened, he had a right to the cloaks of all the lookers on, by ancient custon, and law amongst gamesters; and it was very pleasant to see, that as soon as the ball was in the hole, the standers-by took to their heels, running away with all their might to save their cloaks, laughing and rejoicing, others scurrying after them to secure their cloaks for the winner, who was obliged to offer some sacrifice to the idol of the tennis-court and stone through whose hole the ball had pass'd." (18).

The account set down above is further augmented by that of Brasseur de Bourbourg (4) in his record:

> "The decision was by a number of determined points and the skill consisted for the one of receiving and chasing the ball as their opponents sought to make a pass above the wall that they had chosen for their side. The one who touched it otherwise lost a point. So many points won a certain load of cloth or of chocolate."
>
> "If one of the players succeeded in making his ball pass through one of the rings in the wall this was regarded as a prodigious feat and of happiness without equal. He had the right of taking the cloaks of all the spectators;. . ."

Taking into account the large and heavy ball used, that in a large court such as at Chichen Itza the stone ring was placed 25 feet from the ground, and that the players were restricted from using their hands, it can be appreciated that a goal must have been a rather rare occurrence. The scoring of a goal appears to have ended the game as the players of the winning side immediately pursued the spectators to secure their cloaks for the player scoring the goal. In the case of a smaller court where the ring was set much lower and a goal scored more easily this may not have been the case. The reference to a certain set number of points determining a game would indicate that possibly several goals could be set to determine the winner of a game. No specific account exists which will tell us what was decided in the case of those games which ended without a goal being scored.

The number of players who could participate on a side was quite variable. The game is described as being played as singles, doubles, triples, and various combinations of these figures. The large court at Chichen Itza could have accommodated a great number of players but again no pertinent information on this point has been found.

Duran (13) describes a black and green-colored line which was drawn on the ground straight in front of the stone rings and says that this line was made with a special herb because of religious beliefs. This line divided the playing court into halves but it is not clear whether the line ran parallel to the length of the court or across the court from sidewall to sidewall. Two noted authorities in the field of Mayan archaeology hold opposing views on this question. Blom (3) believes that the dividing line was drawn lengthwise of the court, while Joyce (19) holds that it was drawn crosswise of the court. The importance of this dividing line is mentioned by Duran (13):

> "Those rings also served them as a cord, because straight in front of them (*derecho*) on the ground was a black or green line made with a certain herb, which for reason of superstition had to be made with a certain herb and no other. All the time the ball had to pass this line in which case they did not lose, because even when the ball came rolling on the ground, as they had hit it with the seat or knee as soon as it passed the line, though only two fingers distance, then it was not a default, but counted as such if it did not pass."

The game was similar to modern-day soccer and basketball in that it had players who definitely carried the attack to score while others were used to play guard or a defensive position.

> ". . . and at the ends of the court they had a quantity of players on guard and to defend against the ball entering there, with the principal players in the middle to face the ball and the opponents. The game was played just as they fought, i.e., they battled in distinct units." (13).

A game was started by one of the priests throwing the ball into the air in such fashion that a player immediately received it on the hips or buttocks and put into play. With respect to the length of a game, time divisions, substitution, and other important elements, no definite knowledge is available. Although we know that the object of the game was to score a goal by hitting the ball through one of the rings, we are not even certain which ring was used. It is possible that a goal might have been scored using either ring although this runs contrary to modern-day games in which a specific goal is alloted to each team for scoring purposes. The answer to these questions awaits further research.

The careful construction of the inner playing walls of the courts, much care being expended in securing a smooth and uniform surface, would indicate that the rebounding and angling of the ball from the walls must have been an important skill for the players. While it is not known whether the teams played from one end of the court to the other or crosswise when many players were participating, the main effort must have been to keep the ball between the two side walls and in the vicinity of the stone rings.

The principal players stood between the walls (*A*), and attempted to strike the ball with their hips, buttocks, or knees in such fashion that they could drive it through one of the stone rings. The line mentioned by Duran had to be passed by that team having possession of the ball. One team had to keep the ball on the move while it was on their side of this line and attempt to drive it across into the field of play of the opposing team. In the meantime the other team would be free to interfere within the limits of the rules. The mention of a default counting against the team that failed to carry the ball in their possession across the dividing line probably meant loss of possession of the ball to the opposite team. This would be similar to the rules of modern basketball and similar games.

The courts were deliberately constructed with enlarged ends to pose a hazard for the ball and players were stationed there to stop the ball from entering. Since in all games involving the scoring of a goal the object is to keep the ball near the goal assigned to the team, it is reasonable to assume that such would have been the case in this ball game. In any case, a team which permitted the ball in its possession to be trapped in one of the wide end areas would have a poor chance of scoring a goal from that position. On the huge court at Chichen Itza this would be a physical impossibility.

### Religious Significance

The impression of its deep religious significance is gained from the codices and the presence of numerous stone idols and bas-relief carvings at the actual court sites. Figure I indicates that no less than three temples are an integral part of the Chichen Itza court and religious ceremonies were held in connection

with any game. This is very strongly emphasized by early historians who wrote of the importance of religion in the lives of the people:

> "Every tennis-court was a temple having two idols, the one of gaming, and the other of the ball. On a lucky day, at midnight, they performed certain ceremonies and enchantments on the two lower walls and on the midst of the floor, singing certain songs, or ballads; after which a priest of the great temple went with some of their religious men to bless it; he uttered some words, threw the ball about the tennis-court four times, and then it was consecrated, and might be play'd in, but not before. The owner of the tennis-court, who was always a lord, never play'd without making some offering and performing certain ceremonies to the idol of gaming, which shows how superstitious they were, since they had such regard to their idols, even in their diversions." (18)

Of the presence of stone idols on the walls of the ball courts Clavijero made the following remark (6):

> "The idols placed upon the wall were those of the god of the game, of whose name we are ignorant; but we suspect the name of one of them to have been Omacatl, the God of Rejoicings."

The stone rings at the main court of Chichen Itza have their center holes encircled by two carved serpents with their tails entwining. The Feathered Serpent called Kulkulcan by the Mayas, and Quetzalcoatl by the Aztecs, was a sacred symbol and used in carvings and decorations only in cases wherein it was desired to emphasize strongly something of a religious nature. The carving on the two rings, together with the three temples attached to the court, and the bas-relief carvings on the stone clad slope (*C*) all point to the religious significance of the ball game.

The deities associated with the game varied to a certain extent, as early accounts mention a fairly wide number of different gods and goddesses connected with the game. Duran (13) refers to a stone ring in one of the courts which had the center hole surrounded by a carving which appeared to have been the face of a monkey. Among the Aztecs Xochiquetzal, the goddess of love, lust, and gambling, was considered the protector of the game. At the time of the entrance of the Spaniards into Tenochtitlan, there was a ball court on the central plaza with statues dedicated to Oappatzan and Amapan to whom sacrifices were made at game time (19). The tenacles of ritual extended throughout the gamut of tribal activities, so that all sports and games were thought of in terms of their religious meanings.

A study of the religious connections of the game leads to the conclusion that there must have been two deities associated with it. One of these was connected with the game as a whole while the other was specifically associated with the ball and the stone ring. This conclusion seems to be supported by the studies of Bourbourg (4):

> "The ring had its god or special spirit as well as that of the local god himself and one offered on the occasion of sacrifices to these two divinities. The consecration of the new ball court took place at night, and one practiced there a large number of superstitious rites. For this effect they chose a good day and at midnight the priest of the temple descended to the court; one placed the image of the protecting spirit of the game on the wall, not less elevated than the gallery and on the side opposite one

protecting god of the ball and the stone ring. After the songs and hymns the priest pronounced some mystic formulas and having thrown the ball four times in the interior of the court the consecration of the place and of the equipment found itself ended."

Mention has already been made that a player fortunate enough to score a goal was expected to offer suitable thanksgiving to the ball game deity for his good fortune. In some cases the scoring of a goal was considered an ill omen and the sacrifice made by the scoring player was in the nature of a propitiation. It was undoubtedly the strong religious aspects of the ball game which led the Spanish friars eventually to prohibit its playing.

**Gambling and Professionalism**

At first the ball game was played by the nobles and general populace on a strictly recreational and amateur basis. However, as the sport became more firmly entrenched and began to evolve, professional players appeared on the scene and the character of the game began to change. Lords and nobles vied with one another in keeping the most skillful players for their teams. The purely amateur spirit of the original game is evident in the following excerpt:

"He who hit the ball through said hole in the stone was surrounded by all, and they honoured him and sang songs of praise and danced a while with him and they gave him a certain special prize of feathers or loinclouts, a thing they valued highly, though honor was what he appreciated most and most highly esteemed,. . ." (13)

Before the advent of the professional player, the lords and nobles were accustomed to settle differences by playing a game of ball. This was the case shortly before the arrival of Cortes in 1519. At that period the emperor Montezuma II and Nezahuapilli, chief of the Texcocoans, had a dispute concerning the respective forecasts of their soothsayers. That of Nezahuapilli had prophesied the coming of white strangers to the land. So convinced was the latter of the correctness of this forecast that he wagered his kingdom against three turkey cocks, the result to be decided by a ritualistic game of ball to be played with Montezuma. The Aztec emperor won the first three games in a row but at that time the Texcoco chief made a strong comeback and succeeded in taking the last three games. This inconclusive tie further depressed Montezuma who was at that time exceedingly troubled by the ominous portents of the future (37).

Inevitably the decay and corruption of professionalism made itself felt in the life of the people. A curious parallel exists between our present-day problem of professionalism and gambling and that which confronted the aboriginal inhabitants of Middle America 500 years ago.

"Having recounted the ways of the nobles when playing this game of ball for their recreation and enjoyment, then we will now deal with those who play it for game and as a vice, setting all their happiness and effort-not-to-lose, but to win, as gamblers who have no other business; men who did not live from other sources nor had any other occupation than gambling. Men whose children and wives always lived on borrowed bread and on begging from their neighbors, as even among our Spanish people may happen."

> "What low class people gambled was jewelry and of small value and worth, and as he who has little weath on hand usually loses it, they went to gamble their houses, fields, maize storages, maguey plants, and they would even gamble themselves away to become slaves, to be sacrificed if they did not redeem themselves in time . . ." (13)

The heads of families would become such inveterate gamblers that they would stake their wives and children on the outcome of a game. This aspect of the game at the time of the first Spaniards was undoubtedly a sign of its degeneracy and the coming of the white man probably did little to destroy a sport which was at that time already showing signs of the decay that would have ultimately brought about its end or severe modification.

By the time the Spaniards arrived, the ball game had reached the peak of its development and no further modifications or expansion took place. Since it was banned very shortly by the friars, it came to be played less and less so that one of the last authentic records of its existence is that of Clavijero (6) who cites it as still being played by the Tarahuamare in northern Mexico during the year 1765. It may have continued to be played in isolated communities not closely observed by the clergy beyond this date, but the records are extremely vague.

From the earliest accounts mentioned in the Popol Vuh around the year 700 A.D., the ball game was played up to at least 1765 and probably beyond. This long span of over 1,000 years would make it the longest-played organized team game known to have existed among the aboriginal Americans.

**Summary**

The court ball game unique to Middle America was invented by the aboriginal Mayas about the year 700 A.D. It was called Pok-ta-pok by them and Tlachtli by the Aztecs. The ball game gradually diffused over a period of time so that it was played from Guatemala to southeastern Arizona, as proved by the existence of ball court sites. Its importance in the various cultures of those peoples who subsequently played it is attested to by the many references found in pre-Conquest manuscripts, codices, sacred books, and in the written accounts of the early Spaniards.

Although no definite set of rules has come down to us, the presence of numerous ball courts and other available data have made it possible to formulate a fairly accurate approximation of the way the ball game was conducted. On certain phases, such as the contruction of the courts, definite knowledge is available.

The court ball game became extremely popular with other aboriginal non-Mayan peoples and was being played by them at the time of the conquest. Under the instigation of the clergy, the ball game was prohibited but continued to be played until at least 1765 in a part of northern Mexico. Beyond that date authentic information is not available at this time. The total time during which the court ball game was played ranges from 700 A.D. to at least 1765. This span of almost 1100 years makes it the longest-played organized game known in the New World.

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# The Oxygen Requirement of Walking and Running[1]

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THE OXYGEN resources of the individual, consisting of current oxygen income during exercise plus the oxygen debt, represent a basic physiological limit for large-muscle performance. It is important, therefore, to examine and interpret the presently available knowledge of these resources. The investigation to be described will be limited to the activities of horizontal walking and running in men.

When it is realized that experiments directed to this purpose were made as early as 26 years ago, it might be expected that the problem would be well worked out by the present time. Such has not been the case. For example, in considering important speeds of running such as represented by velocities greater than 6.5 yards per second (approximately the pace of a two-mile run), reliance must still be placed on the results of Sargent's (18) 1926 observations on a single individual. He concluded that the oxygen cost of running increased as the 3.8th power of the athlete's velocity, and this relationship is still expounded in modern textbooks of exercise physiology.

This mathematical function has the characteristic of yielding a straight-line plot on a log-by-log graph such as that of Figure I; the line for his data would

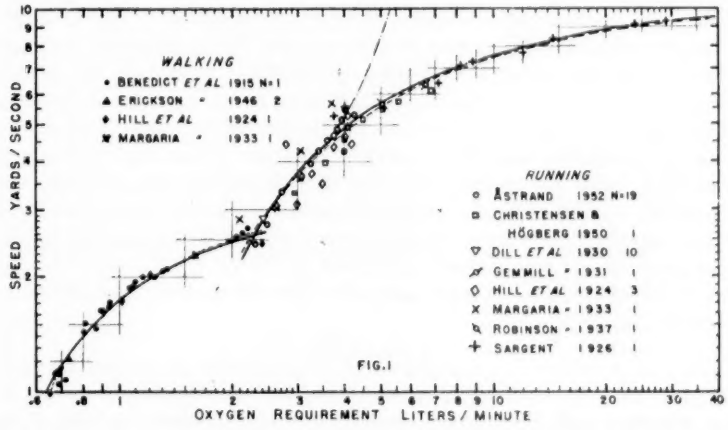


Fig. I. Graphic presentation of basic data on the oxygen requirement of horizontal walking and running. Derivations of the formulae for calculating the smooth curves are given in the text and in subsequent figures.

[1] From the Department of Physical Education.

pass through the points 8.2 liters—7.15 yd/sec., 20 liters—9 yd/sec., and 30 liters—10 yd/sec. The 3.8th power function however does not accurately describe his data, since they show a decided and regular curvilinear trend rather than a linear plot in the log-by-log graph. It should also be noted that the smooth curve of his Figure 2 (which has been widely reprinted in textbooks) is not based on the 3.8th. power function—it is simply a curve drawn to pass through the points.

It is of importance to formulate the correct mathematical law relating speed to oxygen requirement, in order to solve such practical problems as for example the theoretically correct pacing of sprint and middle distance runs (8). Such a formulation must, of course, consider all the available data at all speeds, so they have accordingly been brought together in Figure I. As a matter of secondary interest, the data on walking have also been presented. Unfortunately, most of the experimental determinations have been made on single subjects, hence the sampling error is large and unknown. Dill et al. (5) reported on 10 individuals, but the measurements were made at only one velocity. Astrand (2) has recently published observations on a sizable group of individuals for velocities ranging from 2.4 to 5.3 yds/sec., so the data for this particular region are fairly dependable.

In fitting various mathematical curves to the total data, the writer has used subjective judgment in weighting the various experimentally determined points, holding in general to such criteria as number of individuals, desirability of averaging results from different laboratories, and distinction between oxygen income and requirement as will be discussed later.

**Method**

In order to derive a formula for describing the data mathematically, it will be desirable to change velocity units into units of time required for moving a unit distance. Oxygen requirement will be most conveniently stated in liters per minute, calculated as the sum of oxygen intake (above resting) during the activity and oxygen debt paid off after the exertion, divided by the duration of the activity. It may be postulated that there are two principal factors involved: First, a relatively efficient aerobic (income) factor that does however require an increasing amount of oxygen because mechanical efficiency decreases with increasing speed (i.e., with decreasing time per unit distance) and secondly a comparatively inefficient anaerobic (lactate debt) factor that decreases rapidly in efficiency, particularly at fast speeds. Theoretical justification for postulating these factors is available (9, 10, 11).

One of the mathematical expressions that has the desired characteristics is the exponential equation

$$Y_T = Ae^{KT}$$

where $A$ is the magnitude of $Y$ at zero time, $e$ is the Naperian log base, $k$ is a rate constant, and $Y_T$ is the magnitude of the dependent variable at any particular time $T$. When $k$ is negative, $Y$ is a decreasing function, falling rapidly at first and then more slowly for uniform increases in $T$, in accord with the familiar logarithmic curve form. This function has the convenient property

of yielding a straight-line plot when graphed with a logarithmic ordinate and arithmetic abscissa as in Figure II, so that a graphic determination of the curve-constants can be secured by reading $A$ on $V$ at $T = O$, and computing

$k = \frac{0.693}{T_2} = \frac{2.303}{T_{10}} = \frac{4.603}{T_{100}}$, after reading the $T$ for one-half $A$ or one-tenth $A$ or one-hundredth $A$ as may be desired. It is also possible to determine the constants by standard algebraic methods. Another convenient property is that, where appropriate, the right-hand side of the equation may consist of the sum of several exponentials, with each component adding vertically to give the total $V$ magnitude for any particular $T$ value. Curve systems of this type have wide utility in exercise physiology—they have recently been used to describe the heart rate (19) and oxygen consumption during exercise and recovery (9, 11) as well as the time-velocity relation in sprint running (12).

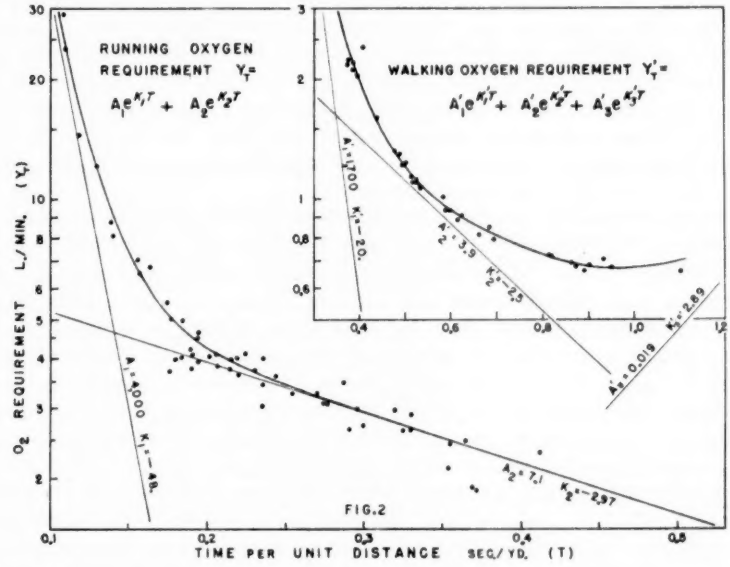


Fig. II. Semi-log plots illustrating the determination of the curve-constants for the theoretical formulae.

## Results

The application of the two-component exponential equation to the basic data is shown in Figure II and by the dash-line curve in Figure I. While the $A_1$ magnitude of 4,000 L/min. might seem fantastically high, it should be realized that this is a mathematical abstraction, representing the oxygen requirement for $T = O$ or infinite velocity, which is of course entirely unobtainable experimentally. The tendency toward a cusp at the oxygen requirement rate

of 4 L/min. is due to the fact that some of the data in this region are based on so-called steady-state oxygen determinations as has been the typical practice for the slower velocities. Actually, the oxygen requirement is subject to a relative increase in this region as shown by Christensen and Hogberg (4), and the steady-state method is therefore inadequate (1).

The broken line in Figure I that branches from the main curve at 3.5 L/min. and progresses concavely upwards is constructed from the $A_2k_2$ component of Figure II. Apparently there have been no systematic investigations of the oxygen intake at progressively increasing speeds between 5.5 and 9 yds/sec. so it is not possible to test the validity of this branch of the curve system except near its point of branching. It should be mentioned that the highest oxygen intake point reported by Astrand should fall between the main curve and the branch in Figure I, since he states that for this point he included only those subjects whose oxygen intake was increasing linearly at the high speeds (*2, p. 128*) which would bias the sample in favor of the high values. For this reason, it is thought by the present writer that his Fig. 53 would have shown the theoretical curvilinear oxygen intake trend at the higher speed if he had included all subjects. It seems reasonable to postulate that oxygen income must approach its limiting value asymptotically in accord with the law of mass action (9); there does not seem to be any mechanism involved that would provide for a linear increase and sharp cutoff.

The insert graph in Figure II shows the fitting of a three-component system to the data on walking oxygen requirement.

It seems reasonable to identify the $A_1k_1$ component with what could loosely be termed a "co-ordination" factor, implying simply that fast limb movement is inefficient, whether the horizontal velocity of the whole body mass is relatively slow as in walking or fast as in running. In the case of running, a factor representing the inefficient anaerobic oxygen metabolism is included in the $A_1k_1$ component; the available data do not permit resolving it from the "coordination" factor. The $A_2k_2$ component probably represents a "normal" or aerobic oxygen metabolism factor in both walking and running; the $k$'s are quite similar and the $A$'s are of the same order of magnitude. The third component, $A_3k_3$, is specific to walking, and has a positive sign attached to the $k$ to provide for progressively increasing oxygen cost at very slow speeds. It may be designated a "static loss" factor. While the quantitative data exhibited do not go to sufficiently low speeds to show an actual increase, the experiments of Lupton (15) have shown that efficiency is decreasing in this region. With a slight readjustment of the $A_3k_3$ constants, this part of the curve could be made either flatter or more curved than has been shown; the experimental facts available are too few to define it very precisely.

Figure III shows that oxygen requirement can be calculated directly from velocity in yd/sec. by the use of appropriate values for the $A$'s and $k$'s. This formula, however, is empirical rather than theoretical. Extension of the $A_2k_2$ component to describe the oxygen intake at higher speeds predicts that the income would increase without limit as shown by curve *3* of the small insert graph of Figure IV. Such a state of affairs is entirely unreasonable physiologically. Curve *2* of the small graph, which is based on the $A_2k_2$ component of

Figure II, is in accord with theory in showing that oxygen income is asymptotically approaching a limit.

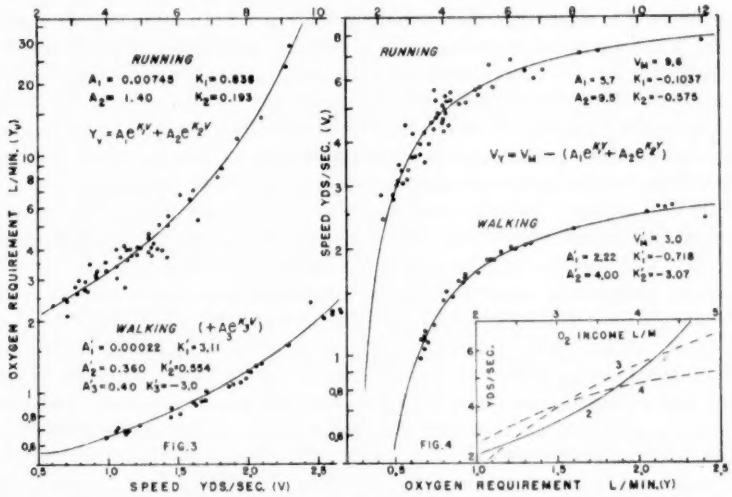


Fig. III. (*left*). Semi-log plot showing agreement of data for empirical formulae for calculating oxygen requirement from velocity.

Fig. IV (*right*). Similar plot for formulae used to calculate velocity from oxygen requirement. Insert graph on linear co-ordinates shows that the aerobic oxygen income component $A_2k_2$ of Figure II approaches a limit in the physiologically correct manner whereas the $A_2k_2$ components of Figures III and IV fail to do so.

It may be desirable for practical reasons to predict speed from known or assumed values of oxygen requirement. A formula for this purpose is shown in Figure IV. In this formula $V_M$ is the maximum possible speed of walking or running as the case may be, for the particular individual whose oxygen requirement is plotted. This limit, estimated from the experimentally determined points at the highest velocities, is approached asymptotically at a rate determined by the sum of the exponential terms. (To save space, the width of the graph has been narrowed so that the last three experimental points are not shown. For oxygen requirements of 14.5, 23.8 and 29.0 L/min. the calculated points are 8.28, 9.12 and 9.25 yd/sec. compared with the experimentally determined values of 8.44, 9.12 and 9.23 yd/sec., hence the agreement is very close indeed). Computations from this formula have been used to draw the heavy line curve of Figure I. While the prediction is empirically successful, the formula is not theoretically meaningful since the $A_2k_2$ component extension (curve *4* of the insert graph of Figure IV) predicts that the oxygen income will increase without limit.

## Discussion

There can be no question that the single individual who furnished the data for oxygen requirements of 7 L/min. and higher showed a progressively in-

creasing requirement for higher speeds, and that the relative increase is greater than the often-quoted 3.8th power law. It may also be conceded that experimental observations on this individual tie in with the other data at lower magnitudes of requirement. Nevertheless, there is a very large sampling error for any data from a single individual, and it must be anticipated that the curve constants for the $A_1k_1$ component will need readjustment as more data become available. While some changes may also prove necessary in the $A_2k_2$ component, they will probably be small, since the sampling is more extensive. There is definite need for active experimentation on the problem, so that sufficient data will be available to establish means and standard deviations for both athletes and ordinary individuals throughout the velocity range. Since several American laboratories now have treadmills and respiratory gas analysis equipment, it is to be hoped that this need will soon be satisfied.

Several suggestions concerning experimental design seem to be in order. Experiments at velocities greater than 4.5 or perhaps even 4 yd/sec should not depend on "steady-state" determinations, but should include both income and debt measurements. Moreover, estimations of the so-called maximal oxygen intake and maximal debt should not be done with some convenient but uninterpretable arbitrary exercise but should make use of horizontal running at known and uniform velocities. A considerable amount of research effort has been expended in recent years in the direction of securing data on grade running to exhaustion, some arbitrary grade such as 8 or 9 percent being used in order to speed up the exhaustion process.

Two questions may well be asked: Where has this research led in terms of quantifying the physiology of athletic performance, and would the same research effort expended in a slightly different direction have led to greater understanding? Perhaps there is need for more frequent inspection of the total available data bearing on the various problems of exercise physiology, so that meaningful blueprints for further work can be constructed.

## Summary and Conclusions

Data from various sources have been brought together in order to formulate a theoretical equation for predicting speed of horizontal walking and running as a function of oxygen requirement. A formula has been derived, based on exponential terms for the oxygen metabolism, that seems to describe the presently available range of data on the oxygen requirement of running. A similar formula involving more general assumptions is found to describe the data on walking. Two sets of empirical formulae are presented for practical use in predicting speed from oxygen requirement and oxygen requirement from speed. The need for more adequate basic data is emphasized.

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# Dynamic Kinesthetic Perception and Adjustment[1]

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KINESTHESIA, the muscle sense, would seem to represent one of the most vital areas for physical education research. However, a search through the pages of the *Research Quarterly* reveals an almost complete absence of concern with this topic. At the date of this writing, the *Quarterly* has published 1,200 articles, of which one third of one percent have been concerned with kinesthesis. Only a single author has professed an interest in the *nature* of kinesthesis.

Wettstone (5), using arm-positioning and target-pointing tests with the eyes closed, found no appreciable correlation between test scores and ratings of gymnastic ability. B. E. Phillips (4) related 10 kinesthesis tests to accuracy in putting and driving a golf ball. One of the tests, "moving a stylus through a winding pathway in the least possible length of time," was (when performed with the right hand but not the left) correlated significantly with putting ($r = 0.38$) but not with driving accuracy. A miniature putting accuracy test, performed blindfolded, correlated $r = 0.33$ with putting accuracy and $r = 0.27$ with driving.

Young (7) studied a number of kinesthesis tests that were scored on the basis of accuracy in arm positioning, leg positioning, throwing or kicking at a target, and reproducing standard pressures on a hand dynamometer. There was no correlation between the arm-positioning tests and accuracy of throwing or hitting a ball, but she did find low positive correlations between leg positioning and kicking at a target. No important relation was found between general motor ability scores and the kinesthesis tests. More recently, Lafuse (2) administered kinesthesis tests before and after a period of training in a "skills clinic." No consistent change was observed; while this result was ascribed to inadequacy of the tests, a bit of theorizing might well question whether practicing a skill should improve a basic sensory capacity. Nevertheless, there does appear to be some justification for the tendency of the authors cited to criticize their own kinesthesis tests on the grounds that they were exploratory and untried, and of questionable reliability and validity.

It should be kept in mind, however, that a test in which "muscle sense" is the only possible cue for a successful response is necessarily a valid test of some aspect of kinesthesis, even though it might be invalid as a test of such abilities as, for example, basketball or golfing. Moreover, it is altogether possible that kinesthesis is a *complex* rather than a unitary thing, perhaps even involving

[1] From the Department of Physical Education. The writer is indebted to the University Board of Research for partial support of the project.

several functions that are relatively unrelated insofar as individual differences are concerned.

Strictly considered, the term *kinesthesis* is defined as the perception or consciousness of one's own muscular responses. "The quality of the sensation is only dimly experienced. It is not totally lacking, as in the vestibular function, but no effort of attending makes it clear and distinct. Man is remarkably well endowed with kinesthetic receptors. No other animal can even approach the precision of timing and delicacy of control that man attains in playing a violin, or in expert drumming, or in dancing, or in walking a slack rope. We are in a class by ourselves when it comes to kinesthesis, and this is in spite of the fact that our *awareness* of kinesthetic sensitivity is never very good (1, *p. 314*).

To avoid confusion, it will be desirable to introduce the term *kinesthetic adjustment* to describe the accuracy of a co-ordinated movement or muscular response controlled by afferent nerve impulses from the muscles, ligaments, tendons and joints, but without the necessary implication of conscious awareness. The need for making this distinction stems from the hypothesis of the present research, namely that accurate kinesthetic adjustment is possible in the absence of the perceptual discrimination.

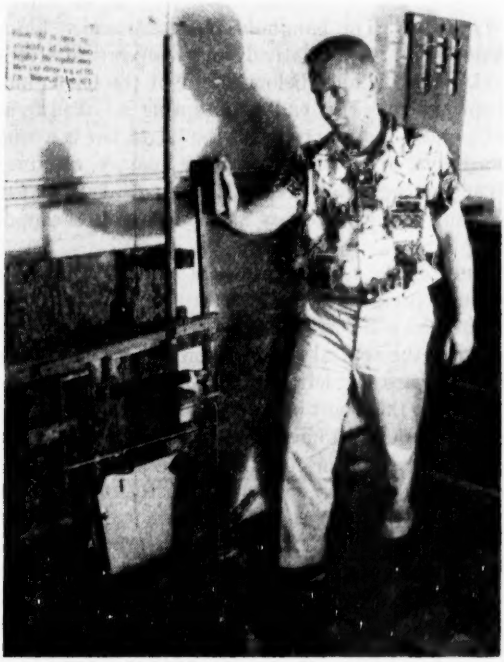

PLATE I. Kinesthesis Test. The subject is of course blindfolded during the actual testing, and has the elbow flexed considerably more than is shown in the photograph.

The muscular action chosen for study is intentionally simple and generalized, depending on an over-all integrated bodily response rather than the

adjustment of a small muscle group. The person to be tested stands on the floor, and exerts forward pressure with his flexed right arm against a movable handhold on the testing instrument. Leg, arm and shoulder muscles as well as joints are involved. The handhold is backed by a spring which the instrument causes to change in tension irregularly throughout the test; the blindfolded subject is expected to increase or decrease his pressure accordingly, so that the handhold does not move. In a separate test, he is required to report whenever he perceives any change in the force of the spring against which he is pushing. In another test, the task is to push against the handhold with a constand pressure always, moving forward or back as necessary when the spring tension changes.

It will be noted that these tests are of a dynamic nature, measuring the accuracy of response to a changing situation, and are therefore quite different from the tests previously used that measure the degree of retention of a kinesthetic image plus the accuracy of a response to that image. Moreover, the proprioceptive impulses from the inner ear probably are at most only a minor factor in the response, which is desirable if interest is centered in kinesthesia.

**Instrumentation and Methodology**

*Kinesthesis Apparatus.* The handhold, a thick wooden block "pad" is attached at shoulder height to a relatively massive vertical steel bar pivoted at $C_2$ (see Figure I). Some distance below the pivot the bar is linked to one end of a horizontal spring. The other end of the spring is linked to another vertical bar pivoted at $C_1$. Near the lower end of the latter bar is a rotating cam that forces it to swing right or left in an irregular manner, altering the tension of the spring and causing the pad to press outward with varying force. (A detailed drawing of the cam contour appears as an insert in the upper part of the figure).

At the lower ends of the two vertical bars there is a *difference* analyzer for use with the constant pressure test. Pivoted to the left-hand bar is a horizontal metal tube, within which slides a rod which is pivoted to the right-hand bar. A cord is attached to the central end of the rod. This cord passes through the inside of the tube toward the left until it reaches a small pulley attached to the side of the tube. At this point it turns downward through a slot in the tube, to bend over another pulley some 12 inches lower down (not shown in the diagram) and on to the recording pen. The cord and pulley shown just above the rod and tube assembly serve to record directly the movement of the pad. The actual position is several inches lower than indicated, the attachment being on an extension of the $C_2$ vertical bar to provide greater sensitivity. This cord is used for the constant position test that will be explained later.

The action of the difference analyzer can be understood by first visualizing the two vertical bars as swinging in parallel fashion under the influence of the cam, while the spring remains at a constant length (which will happen if a *constant* incoming force presses on the pad regardless of its position). In this circumstance, there will be no slippage between the analyzer rod and tube, so the recorder cord will not move vertically more than a fractional inch (although it will of course swing from side to side). However, if the pressure exerted by the

subject on the pad does not exactly balance the spring pressure, the rod will slip within the tube and cause a corresponding vertical movement of the analyzer cord. The cord is connected to a pivoted writing lever on the tape recorder and kept stretched by a small spring attached to this lever. If the subject changes his pad pressure to correspond exactly to the pressure changes caused by the cam, this pen will draw a straight line on the moving paper tape; departures from a straight line will occur in proportion to the discrepancy between the cam-induced changes and the subject's response, i.e., by failure to follow the changes faithfully by pressing with a constant force while the pad moves back and forth under the influence of the cam.

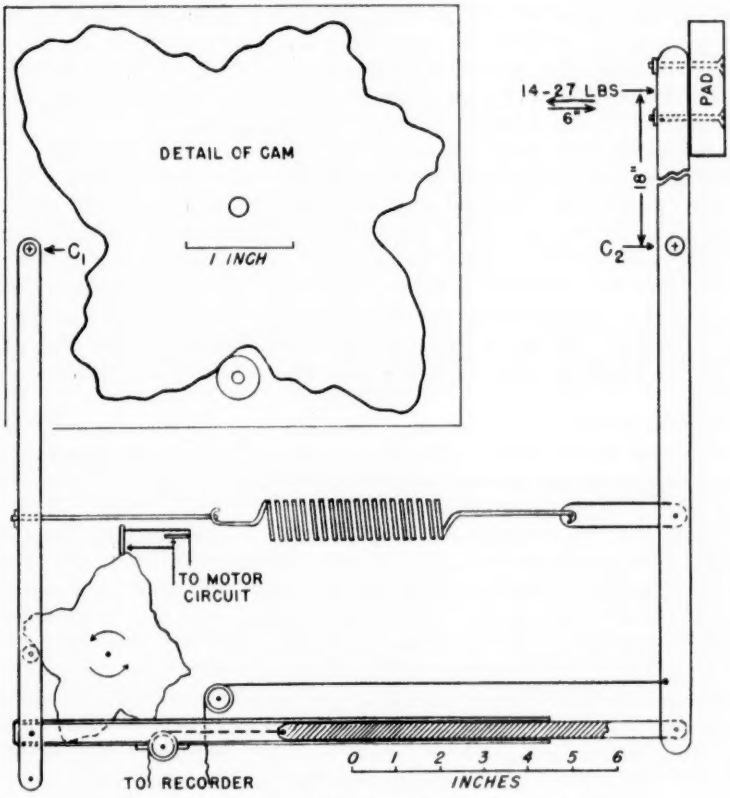


Figure I. Diagram of the Kinesthesis Test Apparatus.

*Details of Construction.* Since the apparatus is original and the forces involved are considerable, some of the more important practical aspects of construction should be mentioned. The various parts are supported on a $\frac{3}{4}$ inch vertical plywood board mounted on a heavy stand and braced against a wall to resist thrust. The pivots $C_1$ and $C_2$ are mounted in commercially available bronze

bearings at both ends. (These may be mounted in holes bored in the wood). The outer bearings are contained in a continuous strip of wood separated from the plywood back by blocks, to form a truss that prevents flexing of the plywood under the applied forces.

A trampoline tension spring, shortened to 28 coils, is attached to the main or right-hand vertical bar by two strips of steel, one on each side of the bar to form a sort of stirrup. During operation of the apparatus, the spring tension varies within the range 44 to 88 pounds, resulting in a pad pressure of 14 to 28 pounds. The pad is a $3\frac{1}{4}$ x $4\frac{3}{4}$ x $1\frac{3}{4}$ wood block. The main vertical bar is made of $\frac{1}{2}$ x $\frac{3}{4}$ inch c.r. steel; the pivot is of $\frac{1}{2}$ inch shafting. The left-hand vertical bar is of truss construction so that the cam lobe can press against the center of the cam roller without interference. It is important that this roller turn freely under pressure. Its shaft is $\frac{5}{32}$ inch drill rod, which is a suitable material for the other pivot shafts (except $C_1$, which should be $\frac{1}{4}$ inch) and also for the left-hand spring hook. Strips of $\frac{1}{8}$ x $\frac{1}{2}$ inch steel form the sides of the truss; the truss spacers are made of $\frac{1}{2}$ x $\frac{3}{4}$ material.

It is convenient to make the cam of $\frac{1}{8}$ inch brass, as this material can be shaped accurately and easily with a Trojan No. 6 extra-fine coping saw blade. The cam must be very firmly brazed or pinned to its hub because of the large forces involved. It is carried on the shaft of a commercially available speed-reducing gear-box; an auxilliary bearing must be provided on the outside end of this shaft. It is desirable to have a circuit-opening switch operated by the cam so that it will automatically stop in a constant position at the end of one cam revolution. The motor is started by a push button shunted across this switch. As presently used, the cam makes approximately one revolution per minute.

The pilot model of this apparatus has a more complicated geometry of its lever systems than is shown in Figure I; however, the principle of operation is exactly as shown, and a second model would take advantage of the simplifications made possible by experience.

*Paper Drive:* The chronograph consists of a Mono Drum variable range high speed synchronous power unit. One of the projecting drive shafts of this unit has been equipped with a 2:1 bevel gear to double the speed, connecting to a horizontal shaft which carries a $1\frac{3}{4}$ x 6 inch paper drive roller. While made of metal, it could just as well have been turned from wood. It is desirable that the middle inch of this roller be 20 or 30 thousands oversize so that the paper will automatically seek the center instead of drifting sideways. It is covered with Gooch chemical rubber tubing, size $2\frac{1}{2}$ inch (flat measure) cemented in place. A single narrow following roller is used to maintain the paper in frictional contact. The writing lever is a flexible strip pivoted 6 inches from a small well-pen, with the cord attached to give half-sensitivity. Five-inch adding machine tape, which is cheap and readily available, is used in preference to special recording paper. Ordinary fountain pen ink has proved more satisfactory than recording ink. A chronograph having the speed range and other features of this instrument is flexible in application and has many uses in physical education research.

*Constant Pressure Test.* The task of *S* (the subject) is to maintain, while blindfolded, a constant pressure on the pad while the pressure changes under

the influence of the cam. Before the cam is started, *S* exerts pressure on the pad under the direction of *E* (the experimenter) until the pivoted arm is vertical. *S* is told to note this pressure very carefully, and to shove his hand forward or to withdraw it as necessary in exact accordance with the movement of the machine in order to prevent it from causing any pressure change. He is then asked to tell *E* what he understands his task to be, and supplementary instructions are given if necessary. The chronograph and cam motors are started and a one minute record secured. After suitable rest, additional records are made. The position of *S* is of course, standardized. The fingers are curled over the top edge of the pad; the elbow is flexed at approximately 45 degrees and held somewhat forward, clear of the torso; the shoulders are twisted about 45 degrees. The feet are comfortably spaced with the left foot back (in a right-handed person).

*Constant Position Test.* The problem confronting *S* is to increase or decrease muscle tension as required so that the changing pressure caused by the cam is always apposed by an equal and opposite pressure exerted by him against the pad. If this is accomplished perfectly, there is no movement of the pad, hence the term *constant position*. Instructions and procedure are the same as before, with the reversal of the terms *movement* and *pressure*. *S* is told to note carefully the pressure caused by the machine and to appose any increase in this pressure by increasing his own pressure; when the pressure decreases he is to decrease his own pressure correspondingly; he is to appose the effort of the machine to make his hand move.

*Subjects.* Data are available for 12 male *Ss*, upper division physical education majors and graduate students. All were extremely co-operative and interested in the tests. Each was given several practice trials before the "official" records were secured.

**Results of the Experiment**

*Perception of Pressure Change.* Holding the arm and body immobile while the cam progressed through one complete cycle of variation, *S* actuated a signal marker once whenever he perceived a pressure increase and made a double mark whenever a decrease was noted. (This was accomplished by tapping the pen cord, which made an easily distinguishable mark directly on the pen tracing.) Later, each tape was superposed on a tracing of the pressure variation caused by the cam, permitting measurement of the distance between the beginning of a pressure change and the response to it. Multiplying these distances by the calibration factor gives the *jnd* (just noticeable difference) for that particular pressure change, and dividing the obtained jnd by the pad pressure gives the *Weber ratio* commonly used as a measure of sensory sensitivity, (6). Multiplied by 100, the ratio gives the per cent change in the stimulus required for discrimination of a change.

By examining Figure II, it may be seen that a majority of *Ss* failed to perceive the change between the start and point *A*. All responded between the major changes *A–B*, *B–C* and *C–D*, and only one failed to notice the pressure increase *D–E*. The smaller changes at *E–F* and *F–G* were missed by over half of the *Ss*, and by a fourth between *J* and the end of the record. The sharp drop

at *A* was reported by only two *Ss*, that at *C* by only three. The sharp rise at *D* was reported by only one *S*; at *H*, the rise had progressed 600 dynes$^{-3}$ before more than one *S* showed awareness of it. Evidently the pressure changes must be as large as 9 or 10 per cent and as rapid as approximately 300 dynes$^{-3}$ per second to be perceived by all *Ss* at all times. If they are as small as 2 or 3 percent they are almost never noticed.

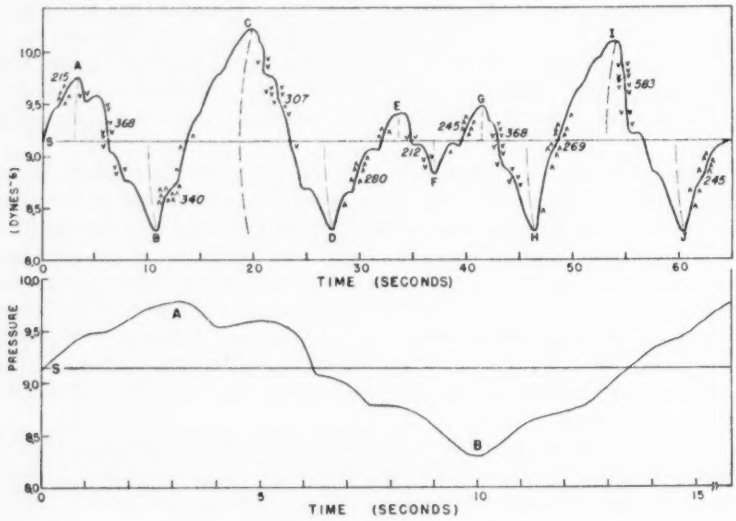


Figure II. Perception of Pressure Change.

*Upper Curve:* Pattern of pressure changes and perceptual responses. The lateral positions of the response marks are not quantitative—they should be exactly on the curve. Vertical positions are correct. The numbers give the average rate of pressure change in dynes$^{-3}$ per second for the region of perception. (445 dynes$^{-3}$ or 0.445 dynes$^{-6}$ equals a force of one pound.)

*Lower Curve:* First portion of pressure change curve taken at faster paper speed to emphasize minor pressure variations. Note that the faster speed largely eliminates radius distortion from the recording pen, which amounts to more than a second in the upper curve (as shown for example by the displacement of point B).

TABLE 1

*Average Difference Limens for Pressure Change*

(Units are dynes$^{-3}$; rate is pressure change in dynes$^{-3}$ per second. Location of determination on pressure change cycle shown in Figure II.)

| | Location | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | A–B | B–C | C–D | D–E | G–H | H–I | I–J | Average |
| M | 516 | 444 | 606 | 638 | 449 | 820 | 443 | 559 |
| SD | 264 | 239 | 214 | 208 | 187 | 234 | 183 | 220 |
| Rate | 368 | 340 | 307 | 280 | 368 | 269 | 583 | 359 |
| Weber Ratio | 0.056 | 0.050 | 0.063 | 0.073 | 0.049 | 0.089 | 0.046 | 0.061 |

The average difference limens (i.e., sensory thresholds for pressure change) are summarized in Table 1. These data include only those parts of the pressure cycle that elicited responses from all *Ss*, except for *D–E* where one *S* missed. It can be seen that there is a marked tendency for the observed sensory acuity to be dependent on the rate of pressure change—the poorest discriminations, 8.9 and 7.3 per cent, occur with rates of 269 and 280 dynes$^{-3}$ per second whereas the best discriminations, 4.6 and 4.9 per cent, are found when the rates are highest, namely 583 and 368 dynes$^{-3}$ per second.

Five *Ss* were well trained in kinesiology and had considerable psychological background. These men subsequently went through the test repeatedly for the purpose of an introspective analysis. Opinion was divided as to what could be loosely termed "the task as it is perceived by *S*." One reported a visualization of the pivoted vertical bar which was prevented from moving by appropriate muscular adjustment. Two visualized the pad as just being in space, with *S* counter-acting a tendency for it to move by easing or increasing his push. The other three had a less clear perception—it was a matter of pressure changes occurring and *S* responds by increasing his thrust against an increase and lessening it against a decrease. All agreed that most of the time *S* just pushed against the pad and had no perception whatever of any change in pressure. Pressure changes, when they *were* perceived, were most frequently localized as tension changes in the triceps and next most frequently in the anterior deltoid, often but not invariably associated with an awareness of altered pressure against the distal part of the hand. Occasionally they were felt as changes in the tension of the leg muscles. The perception was diffuse; *S* preferred to just say that when the pad pushed harder against him he pushed harder against it. In no case was there any report of perception of joint movement.

*Base Line Drift.* During the constant position test, three of the subjects held the original position almost exactly for the entire 64 seconds duration of the test and one showed only a very small change. Four tended gradually to push harder during the period, ending up with an average increase of about 500 dynes$^{-3}$. The other four tended to ease up on the pressure to the final extent of 600 dynes$^{-3}$. The average for the group, therefore, shows relatively little drift, but the variability of the drift scores shows a tremendous increase toward the end of the test (Table 2). Since nearly every subject complained (when questioned) that it was fatiguing to push the pad continuously for over a minute, it may be surmised that this variability of base line drift is linked up with a fatigue effect. It seems probable that some subjects decreased their pressure because of this influence, some successfully compensate, and some over-compensate.

TABLE 2

*"Drift" During Constant Position Test*

| Time (seconds) | | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|
| Movement of pad (inches) | M | 0.018 | 0.028 | 0.075 | 0.049 | 0.064 |
| Change in pressure (dynes$^{-3}$) | M | 11 | 26 | 71 | 47 | 61 |
| Standard deviation | SD | 167 | 297 | 382 | 209 | 543 |

*Position Constant.* Since the test was concerned with the ability to counter an imposed pressure change by an equal and opposite change in applied pressure, the base line drift represented an experimental error. It was largely eliminated by drawing a secondary base line along the trend of each individual curve and measuring the scores at points *A*, *B*, *C* etc. as deviations from the new base line. The results are summarized statistically in Table 3. In order to relate them to the varying pressure from the cam, these averages and interposed averages taken at the points of minor pressure changes have plotted in Figure III just below the curve showing the imposed pressure change pattern. In this figure the ordinate is calculated in pounds, since many readers will find these units more familiar than the C.G.S. units.

TABLE 3

*Error of Response to Changing Pressure*

Mean error and its standard duration, in dynes$^{-3}$, of the reaction to successive increments and decrements of pressure. (Points of measurement are shown in Figure II.)

| | | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Position | M | 33 | −19 | 31 | −7 | 30 | 35 | 31 | 34 | 59 | −11 |
| Constant | SD | 53 | 51 | 77 | 64 | 102 | 108 | 77 | 77 | 74 | 45 |
| Pressure | M | 586 | −366 | 258 | −336 | 143 | −89 | 177 | −393 | 326 | −285 |
| Constant | SD | 155 | 321 | 310 | 427 | 212 | 223 | 180 | 181 | 440 | 430 |
| Difference | M | 553 | −347 | 227 | −329 | 113 | −124 | 146 | −359 | 267 | −274 |
| Critical Ratio | t | 11.3 | 3.9 | 2.7 | 2.7 | 2.1 | 2.2 | 3.1 | 8.6 | 2.2 | 2.5 |

It is obvious by mere inspection of the data that the required muscular adjustment is made with high precision. Individual records without exception, as well as the group averages, show a surprising accuracy in countering all imposed pressure changes, both major and minor, with appropriate and exact adjustments of muscle tension. This holds true even if there is no allowance for drift, although the evidence is more spectacular when this justifiable correction is made.

These findings are even more remarkable when contrasted with the relatively poor perception of the pressure changes. On the average, the error of adjustment was 29 dynes$^{-3}$ whereas an average pressure change of 559 dynes$^{-3}$ (nearly *20 times* larger) was required for perception. The *t* ratio for the difference between these averages is 7.6. Evidently *S* has the ability to respond to changes in applied pressure by altering muscle tension in the absence of conscious awareness of the pressure changes.

*Pressure Constant.* The results with this test also appear in Table 3 and Figure III. To interpret the figure, one must keep in mind that, since the curve is a record of the difference analyzer, a perfect response would be a horizontal line just as in the case of the other test. On the other hand, if *S* holds *position* constant and the pad pressure is permitted to vary as the cam determines, the analyzer will draw a line that will superpose on the cam pressure change graph.

It will be noted that this is exactly what happened near the end of the "typical subject" record; for some unexplained reason *S* froze his position at this point. Assuming some degree of success in maintaining the pressure constant, points on the average curve can be expected to fall somewhere between the base line and the outline of the cam pressure curve if drift corrections have been made. It is quite possible for individual curve points to fall outside that outline, and some of the records show that large errors of this type have occurred.

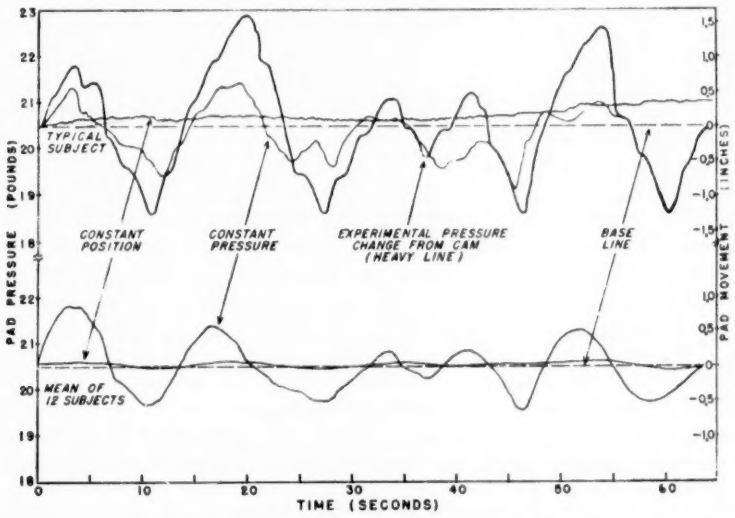


Figure III. Kinesthetic Adjustment to Pressure Change.

*Upper Curve:* Superposed constant position and constant pressure records of a typical subject. The experimentally produced pressure change (for constant position) and movement change (for constant pressure) is also shown for comparison.

*Lower Curve:* Average response of the 12 subjects in the two tests.

As was mentioned in connection with the constant movement test, certain implications of the data are obvious by mere inspection. It is clear that this is a very difficult test—while there is some degree of success in maintaining the pressure constant during the cam variation cycle, the general picture is one of failure rather than success. All individual records without exception show relatively high success in holding position constant and relatively low success in holding pressure constant.

*Comparison of Accuracy of Response on the Two Tests.* The differences in scores between the constant position and constant pressure tests have been statistically evaluated by the *t* ratio method as shown in the bottom line of Table 3. Since the hypothesis being tested predicts the direction of the difference, a one-tailed distribution of *t* must be assumed. With 11 degrees of freedom, a *t* ratio of 1.8 is statistically significant at the 5 per cent level of confidence; a *t* ratio of 2.7 is highly significant since it reaches the 1 per cent level.

Thus, by conventional standards, there is a statistically significant difference in favor of the constant position test in all ten comparisons and the difference is highly significant at more than half of the measured points on the cycle.

**Discussion**

Psychologists have in the past been concerned with such kinesthetic problems as the ability to perceive which of two lifted weights is the heavier. One of the more recent and extensive studies, that of Oberlin in 1934, reports a Weber ratio of 0.019 (according to Woodworth). While this is considerably smaller than the average ratio of the present experiment, namely 0.061, the 200 gram weights that were used would result in a force only a fiftieth as large. This may well be the cause of the difference since the Weber ratio for all sense modalities tends to increase for large stimulus magnitudes (6).

While it is impossible to analyze the sensory basis of the perception in detail, it is interesting to compare the results with the Weber ratios for deep pressure (0.013 for a 390 dynes$^{-3}$ stimulus) and cutaneous pressure (0.136 for a 5 dynes$^{-3}$/sq.m.m. stimulus). The latter figure is so high that it is doubtful if cutaneous pressure is a very important contributor to the perception. Joint movement could well have been a factor, since the passive elbow movement limen, for example, is reported to be 0.4° (3). The currently observed perceptual limen, if assumed to be entirely due to elbow flexion, would be about 2.9°, and one-seventh of this amount of movement should be perceptible. Concerning the perception of muscle tension as such, nothing can be said, as the writer has been unable to find any data on this modality. The introspective reports, it will be recalled, tended to emphasize the perception of muscle tension, although no single factor was clearly of major importance.

The "kinesthetic adjustment" test that was most similar to the perception experiment was of course the constant pressure task. The over-all average accuracy in this test, stated as a Weber ratio, was 0.035 compared with the figure of 0.061 for the perception. Considering the additional burden placed on *S* when the perception reports were required, and the necessary differences in method, this in the writer's opinion constitutes reasonably good quantitative agreement. On the other hand, the tremendously greater accuracy of adjustment in the constant position test is of a different order of magnitude, and cannot be explained quantitatively in terms of known facts of perception. While the basic afferent neurological information involved may have been the same (except that joint movement was almost completely excluded), the integration must have taken place at more of a reflex level. It will be interesting to see the degree of relation between individual differences in the two functions. This problem, and determination of the contribution of each of the functions to ability in acts of skill, as for example gymnastics, are in process of investigation.

**Acknowledgement**

The development of the dynamic kinesthesis test was a joint project of the writer and his colleague, Hugh Mumby, who was specifically interested in

studying the role of kinesthesia in wrestling ability. Preliminary results on the latter problem appear promising, and will be reported in a separate paper.

## Summary and Conclusions

Two types of kinesthetic adjustment were studied with respect to accuracy of response. In one, the subject was required to press against a spring-loaded lever, while blindfolded, varying his pressure in such a manner that the lever did not move even though the spring was caused to vary irregularly in pressure by the action of a motor-driven cam. In the other, the subject moved his arm and body backward or forward as necessary in order to maintain a constant pressure on the lever. In another test, the subject signalled whenever he perceived a change in the pressure exerted by the lever.

Analysis of the data from 12 male subjects reveals a reasonably close correspondence between the average perception of pressure change and ability to respond by maintaining a constant pressure during the irregular cam cycle. The mean error in response was a force of 0.71 lbs., compared with an average of 1.25 lbs. increment required to perceive a change in pressure. In marked contrast to these results, the average error of the constant position adjustment was only 0.065 lbs. In view of the fact that the error of the latter adjustment was so far below the perceptual threshold, it probably represents a reflex response to the applied pressure changes.

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# Duties of the State Directors of Health and Physical Education

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THE DATA REPORTED here were supplied by the state directors of health and physical education. The information has been selected from a doctoral study completed in 1951.[1]

**Procedures**

From a survey of the available literature on the administration of health and physical education and interviews with three selected state directors, a preliminary checklist of the duties of the state directors of health and physical education was constructed. It was criticized by three authorities in the field of health and physical education and three competent educators outside the field of health and physical education. The preliminary checklists, consisting of approximately 600 items, were submitted to five state directors in a pilot study. Space was allowed for additional items considered important by these directors. The directors also deleted items they did not consider relevant.

From the results of the pilot study a final checklist was constructed with the heading "An Analysis of the Duties of the State Directors of Health and Physical Education in the United States." These checklists were sent to all state directors (39). There was 100 percent response.

**Treatment of Data**

The data were organized into three major parts. Part One contained general information about the directors, viz., experience, educational history, and the legislative acts, rules, and regulations pertaining to the directors.

Part Two contained the general administrative tasks involved in carrying out the duties of the director, viz., planning the program, work with other state departments, staff associates, teachers in the field, school administrators, professional colleagues outside of own state, work with state universities, colleges, and state teacher education institutions, clerical activities, publications, professional advancement, and tasks involved in the management of state health and physical education facilities and equipment.

Part Three indicated the degree of responsibility involved in carrying out the specific duties of the directors in connection with Health Instruction,

[1] James Clifton Loveless, *An Analysis of the Duties of the State Directors of Health and Physical Education in the United States*, Doctoral dissertation, Indiana University, Bloomington, Indiana, 1951. Detailed information concerning the duties may be obtained from the author or in the dissertation.

Health Service, Physical Education, Recreation and Camping, Safety Education, and Interscholastic Athletics.

**Summary of Findings**

The following findings are based on data furnished by the state directors.

GENERAL INFORMATION

1. Thirty-nine states have state directors of health and physical education.
2. There are many different titles applied to this state school official. "Director" is the most frequently mentioned title.
3. Minimum educational requirements for the state directors are not uniform in the states. Thirty-three states have definite requirements and six states have no specified requirements. The most frequently mentioned requirement is a Master's degree.
4. Likewise, minimum experience requirements for the directors vary in the states. In 14 states there are no specified requirements concerning experience. In 13 states "teaching" is a requirement. One state requires experience in both teaching and administration. In some states the requirements are vague, such as; "experience in successful program," "five years responsible experience," or "successful experience."
5. The directors, as a group, are professionally minded. Ninety-seven percent of them belong to one or more professional organizations and they subscribe to and read many different professional magazines. *The Journal of the American Association for Health—Physical Education—Recreation* is the most frequently read professional magazine.
6. The state directors of health and physical education have a certain amount of stability in the length of tenure in office. Twenty-five state directors indicated that there was no law or regulation governing the length of the term in office. In ten states tenure is permanent. The median number of years of service for present incumbents is 3.85.
7. Practices and policies differ widely in the states. The lack of uniformity of many of the directors' duties tends to bear out this fact. Yet in the midst of differences, there are duties relating to certain important policies and practices on which there is a measure of agreement. It is significant that in 45 states there are laws requiring health examinations of pupils; in 42 states there are laws enabling the schools to offer courses in health and physical education. In 32 states health and physical education courses are required for graduation. Thirty-six states have guides or courses of study for the different areas of health and physical education.

ADMINISTRATIVE DUTIES

8. The administrative duties of the directors of health and physical education are many and varied. They are a major concern of the director. Of the total 111 general administrative duties, 76 are considered duties of greatest importance (in this study duties performed by at least 50 percent of the directors

are considered duties of greatest importance). The duties summarized in paragraphs 9 to 18 are those performed by at least 50 percent of the directors.

9. Planning the program is a major concern of all directors. They set up general objectives, decide on policies, survey needs in the state, and consult with the superintendent of public instruction on matters concerning the department. They read professional literature and list priority jobs in each field, e.g., physical education, recreation and camping, etc.

10. The directors are responsible for arranging for special contributions to publications. They edit and distribute publications.

11. The directors are responsible for planning and co-ordinating activities, such as; clinics, hobby exhibits, demonstrations, etc. They make written reports of these activities.

12. The directors have significant duties relating to their own staffs. They assign duties to the staff members; work with associates on special projects, such as publications, workshops, handbooks, and demonstrations; confer with and advise individual staff associates; serve on departmental committees; plan, schedule, and attend departmental meetings; act as chairmen of such meeting; and substitute for associates in case of emergency.

13. The greatest number of administrative duties concerns clerical activities. This is not surprising as the state office of health and physical education is at the apex of the organization of the health and physical education program in the state and functions to co-ordinate its services for the entire state. These duties include the preparation of special reports on health programs, workshops, school facility surveys, physical examinations, and medical examinations. The directors prepare mimeographed materials, periodic reports, record cards, book lists, charts, calendars, and exhibits. They write business letters, write and send out questionnaires, write articles for professional publications, and make out requisitions for supplies.

14. The directors consider it a duty to attend professional meetings, serve on committees, serve in an official capacity, and contribute to convention programs. Many write articles, conduct research projects, and attend special graduate courses.

15. The directors encourage the health and physical education teachers in the field by helping them with problems of organization, providing program materials, participating in their local meetings, helping them with problems of professional advancement, encouraging them to participate in state level plans, and they stimulate local research. They encourage the teachers to help formulate curricula and help them with interschool relations.

16. The directors aim to maintain friendly relations with school administrators in the field, keep them informed on matters of policy, and acquaint them with services available from the state department. It is their duty to advise the administrators on matters concerning organization of departments of physical education, school health, safety education, and recreation and camping. They act in an advisory capacity on problems relating to the construction of facilities for health and physical education. They advise in relation to work of school dentists, doctors, and nurses. They set up school health committees. They work

with the administrators concerning school camps, school lunches, and the control of hygiene of school environment.

17. Most directors work with professional colleagues in other states. They exchange ideas and co-operate with other directors at interstate, area, and regional conferences. They also advise other directors of new legislation, rules, and regulations activated in their states.

18. Most of the directors consider it a duty to direct workshops, lecture at teacher-training institutions, and advise on teacher-training requirements. The great majority co-operate with officials in schools other than those state supported.

19. Very few directors work in public relations programs, consult with health commissions, have long-term plans, co-operate with other state departments, keep money accounts, serve as consultants to colleges and universities, or advise on their health and physical education curricula. Few advise authorities on the purchase and maintenance of state department facilities.

SPECIFIC DUTIES

20. The state directors perform 109 specific duties in the area of Health Instruction, Health Service, Physical Education, Recreation and Camping, Safety, and Interscholastic Athletics. Eighty-two duties are considered duties of greatest importance. These are summarized in paragraphs 21 to 26.

21. In the area of Health Instruction the directors develop courses of study, advise on textbook adoption, supply supplementary teaching aids, and conduct in-service training for teachers. They maintain libraries and provide audio-visual materials. Many supervise health instructions, provide standards to evaluate teaching, initiate workshops, forums, conferences, institutes, etc., and serve as liaison between teacher-education institutions and the state departments. They certify health teachers, administer health projects, distribute publicity, conduct radio programs, and write professional articles pertaining to health instruction.

22. The directors have significant specific duties in the area of Health Service. They co-ordinate health service with the physical education program. They interpret the school health program and national trends in health to local educators and interested agencies. Most of the directors initiate health workshops, study programs, conferences and institutes, and publicity on state and local levels. They promote laws and regulations pertaining to school sanitation, and school construction (mainly lighting, water, toilets, feeding facilities, etc.). They promote enabling laws for adequate health programs. They set up standards for health service programs and advise on requirements for personnel working in the program. They construct cumulative record cards, furnish information to lay inquiries, and enlist the support of voluntary agencies. They supervise nutritional services and conduct in-service training for health service personnel. Many establish educational policies and principles concerning the health service programs and school health environment.

23. There is great uniformity in the performance of specific duties in the area of Physical Education; over 75 percent of the directors perform 17 of the

20 duties mentioned. The directors define and enforce minimum program standards, set up standards and policies pertaining to physical education in the schools, provide standards for program evaluation, and provide supervision for physical education programs in rural districts. They promote necessary and appropriate legislation to enable cities and school districts to conduct physical education programs, approve plans for new construction of facilities, interpret the physical education program to the public, and interpret national trends to school administrators. They furnish leadership for in-service training for teachers, set minimum requirements governing certification of physical education teachers, conduct demonstration schools, and direct research on state and local levels. They construct courses of study, evaluate and disseminate teaching aids, provide pupil cumulative record cards, and maintain audio-visual aids libraries.

24. There is little uniformity among the directors in performing the duties in the area of Recreation and Camping. The directors interpret policies of the state department of education pertaining to recreation and camping. They interpret the school recreation program to private, semi-private, and voluntary agencies. They initiate and promote legislation enabling local school boards to obtain tax monies to finance community recreation programs. Many directors report it their duty to serve on state level committees, promote the use of their states' natural resources for recreation, and publicize the services offered by the state departments. They advise local boards of education on the acquisition and lease of property for recreation purposes. They act as liaison between the state departments of education and other state level agencies and groups interested in recreation and camping.

25. Safety Education is a major concern of the directors. They interpret policies, rules, and regulations of the department of education as they relate to safety. They interpret the school safety program to interested organizations and initiate appropriate legislation to enable cities and school districts to conduct safety programs. Most of the directors develop courses of study, provide teaching aids, and set up standards for safety education. The directors advise school authorities concerning motor traffic clubs, junior safety councils, first aid clubs, etc. They serve on safety committees, conduct state-level campaigns for accident prevention, and direct desirable research activities in safety education.

26. It is significant that on the basis of frequency of mention the duties pertaining to Interscholastic Athletics are performed by very few state directors. Only one duty "set up minimum standards for certification of athletic coaches" is performed by more than 50 per cent of the directors. Thirty-three per cent have some responsibility for the "control" of junior high school interschool athletic contests.

27. Very few directors have specific duties pertaining to psychiatric services, direct state contests in such activities as gymnastics and rhythmics, enforce regulations pertaining to athletic contests in high schools, supervise insurance plans for athletics, or supervise state athletic contests. Only one state director serves as commissioner of high school athletics and only eight directors reported

it a duty to serve as a member of the governing board of high school athletics.

28. It is significant that the specific duties are performed with varying degrees of responsibility—*absolute*, *advisory*, or *cooperative*.[2]

29. On the basis of percentage of possible frequency of mention of duties according to *absolute responsibility*, the areas rank as follows: Physical Education, 22.44 per cent; Health Instruction, 16.18 per cent; Safety Education, 15.9 per cent; Recreation and Camping, 11.44 per cent; Health Service, 7.69 per cent; and Interscholastic Athletics, 4.06 per cent.

30. On the basis of possible frequency of mention of duties, according to *advisory responsibility*, the areas rank as follows: Safety Education, 34.10 per cent; Health Service, 28 per cent; Health Instruction, 23.88 per cent; Physical Education, 22.56 per cent; Recreation and Camping, 20.03 per cent; and Interscholastic Athletics, 14.52 per cent.

31. On the basis of percentage of possible frequency of mention of duties according to *co-operative responsibility*, the areas rank as follows: Health Instruction, 41.97 per cent; Physical Education, 38.84 per cent; Health Service, 36.53 per cent; Safety Education, 33.33 per cent; Recreation and Camping, 22.59 per cent; and Interscholastic Athletics, 8.09 per cent.

32. On the basis of frequency of mention according to the degree of responsibility, most of the specific duties of the state director of health and physical education are performed on a co-operative basis, many of the duties are performed on an advisory basis, and few of the duties are performed on an absolute basis.

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[2] *Absolute responsibility* is to be interpreted as having independent responsibility and complete authority.

*Advisory responsibility* is to be interpreted as having or exercising power to advise; it connotes the power to counsel, to recommend or support.

*Co-operative responsibility* is to be interpreted as having responsibilities for decisions shared with personnel in other departments or other departmental divisions.

# The Effect of Posture on the Brachial Sphygmogram as an Indicator of Cardiovascular Condition

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THERE IS available to physical educators a relatively simple and easily operated instrument, the Cameron Heartometer (1, 3: p. 232), which records arterial pulsation. A blood pressure cuff is wrapped about the desired location and inflated to a pressure somewhere between that of systolic and diastolic blood pressures. The pressure of the air in the cuff is increased with each arterial pulsation, and this change is pneumatically transmitted through rubber tubing to an aneroid membrane. The movements of the membrane are recorded on a rotating paper disc, by means of a small glass pen attached to the end of a lever (Fig. 1). The magnitude and form of the tracings are determined primarily by: (1) the volume change of the limb under the cuff, (2) the mechanical characteristics of the recording instrument (6), and (3) the pressure in the cuff relative to systolic and diastolic blood pressures (5, 8).

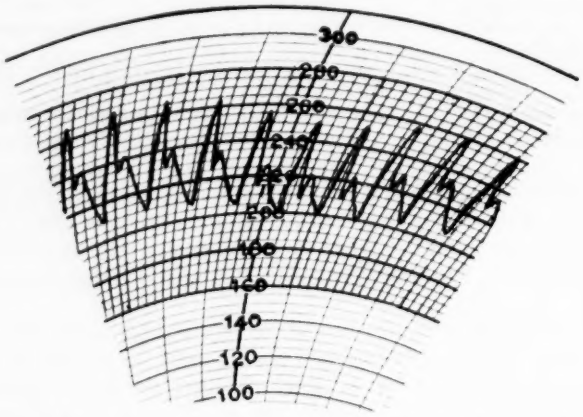


FIG. 1. Typical Brachial Pulse Tracings Recorded with the Cameron Instrument.

Studies have been under way for several years at the University of Illinois in an effort to determine whether Heartometer tracings of the brachial pulse wave can be used as indicators of cardiovascular fitness. The criteria of cardiovascular fitness used in these studies have been predominantly of the endurance performance type. Willett (14), using 61 male students, found that the amplitude of the wave's initial upsurge (systolic amplitude, Fig. 2), amplitude of the

catacrotic surge (diastolic amplitude, Fig. 2), the slope of the initial upsurge as indicated by a measurement termed the obliquity angle, and the overall area under the curve correlated .53, .56, −.51, and .47, respectively, with the length of time the subjects could run at seven miles per hour on a motor driven treadmill.

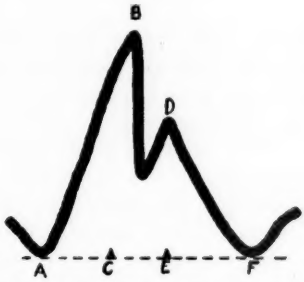


FIG. 2. Diagram of a Pulse Tracing Indicating Primary Components. Dotted line at base of wave used as reference line for measurement of components; ABF = area of wave; BC = systolic amplitude; DE = diastolic amplitude.

Cureton (4, *pp. 252–254*), summarizing all of the studies completed at the University of Illinois, reported that the brachial wave recorded with the subject quietly sitting not only correlated with running endurance, but also differentiated groups believed to differ in cardiovascular fitness. The waves of champion swimmers and track men, for example, averaged greater in amplitude and area than did those of medical school Freshmen. Cureton (4, *p. 234*), citing a single case study, reported that the waves increased in area and diastolic amplitude with training. Michael (9), using a sample of 18 young male adults representing all levels of normal fitness, found that the area and systolic amplitude of the brachial waves correlated significantly with the stroke output of the heart as estimated by the Grollman acetylene procedure. In brief, the Illinois research has indicated that a relationship exists between sphygmogram form and various criteria of cardiovascular fitness. These studies, however, have been carried out only with tracings recorded in the sitting position.

The purpose of this study was to determine whether heartometer brachial pulse waves recorded with the subjects in the lying or standing position, or measures based upon wave differences due to the effects of posture, demonstrate more statistically significant mean differences between groups formulated on the basis of a criterion of cardiovascular fitness, than do waves recorded in the sitting position.

**Procedure**

*Subjects.* Subjects for the study were solicited from groups believed to differ in endurance fitness. Seventy male University of Maryland students, ranging in age from 17 to 27 years and in sufficiently good health to participate in required physical education, volunteered to be tested. Fifty were members of the required physical education program, two were physical education majors, three were varsity boxers who had just completed a season of boxing, and 15

were members of the Maryland cross-country and track teams, all of whom had worked out regularly for several weeks prior to being tested.

*Data.* The data obtained were brachial sphygmograms in the lying, sitting, and standing positions, time for an 880-yard run, height, weight, and previous sports experience. All tests were administered between November 1, 1950 and June 1, 1951.

*Recording the Pulse Waves.* Pulse waves were recorded with a previously unused instrument which had a natural frequency of approximately 5/sec. All tracings were obtained in the same location with the same instrument and operator. The subjects were asked to obtain a minimum of six hours sleep the night before the test; not to eat, drink, or smoke within two hours of testing; and not to exercise vigorously on the day of the test. The subjects, upon reporting for testing, were measured for height and weight. They then rested sitting for five minutes. During this time oral and room temperatures were recorded, and a data sheet concerning the subjects' activities for the past 24 hours was filled out. After resting, the subject moved approximately three yards and assumed the initial posture for testing. The cuff (a snap-on cuff instead of a wrap cuff, since it has less tendency to slip with shifts in body position) was wrapped about the left upper arm, care being taken to place it in the same position for all subjects. The initial posture for recording was rotated throughout the group in order to eliminate possible bias.

The sequence of position change for all but one subject was lying to sitting to standing to lying. In each position a minimum of three minutes elapsed before a record was taken. During this interval the pressure recording of the heartometer was checked against a mercury column. In each position tracings were made at several cuff pressures so as to obtain waves of optimum amplitude and area. Supposedly, this compensates for the effect of diastolic blood pressure. The cuff pressure after each recording was reduced to a point below diastolic pressure restoring arm circulation. The arm position for the lying posture was at rest beside the body; in sitting, the arm rested on a table with the elbow slightly bent; and in standing, it rested on an adjustable support in the same position as for sitting. Seventeen subjects volunteered for pulse wave retesting, thus providing data for a reliability check. The retest was administered within two weeks of the first test.

*880-Yard Run.* The 880-yard run was administered to all subjects within a period of 33 days of the quiet tests. One subject ran on the same day as the pulse wave tests, and 58 ran within an 11-day period. The runs were performed, depending on weather conditions, outside on a quarter-mile track or inside on a tenth-of-a-mile track. Time was recorded in minutes and seconds.

*Sports History.* Sports history was obtained by use of a questionnaire on which the subject checked the sports in which he had participated, level of competition, and approximate length of time.

**Treatment of the Data**

*Measurement of the Pulse Waves.* The variables considered in this study were systolic amplitude, diastolic amplitude, and pulse rate in the lying, sitting, and

standing positions; and items based on differences in these components resulting from postural effects. Systolic amplitude and diastolic amplitude were selected on the basis of Willett's (14) recommendation and available information concerning the mechanical characteristics of the instrument (6). Pulse rate was included as a matter of interest.

Representative pulse wave measurements for use in the statistical analysis were derived by selecting from each heartogram three consecutive, regular, maximum sized waves. The amplitudes of the components were measured with vernier calipers and averaged. Pulse rate was computed by counting the number of pulsations occurring in three six-second periods, converting to a per-minute basis, and averaging.

*The Criteria.* The criteria of cardiovascular fitness used in this study were essentially of an endurance type. The subjects were grouped in three different ways: (1) on the basis of 880-yard running times, (2) past sports activities, and (3) the University of Maryland physical activity groups from which they were solicited. The 880-yard run, rather than a longer distance, was selected because of the reluctance of subjects to volunteer for longer distances. An endurance performance such as this, although determined by many factors, is generally accepted as indicative of cardiovascular condition. There is believed to be a relationship between circulatory efficiency and endurance capacity and/or state of training (4, *pp. 252–254*; 10, *pp. 281–283*; 12, *pp. 150, 179*). The grouping on the basis of sports activity, both past and present, was premised on the idea that persons who have participated in vigorous, competitive sports have through such activity possibly developed more efficient circulatory mechanisms or have been successful in sports, at least in part, as a result of superior circulatory efficiency.

**Analysis of the Data**

Analysis of the data was carried out in four phases. Review of the personal data sheets revealed that all subjects had not complied with pre-test instructions. The recordings of those tested under relatively controlled conditions and having usable tracings for all three postures were selected for an initial analysis, Phase I. This was done with the small, controlled sample so that components which were not significant could be omitted from further measurement and analysis. The criteria used in this selection were: a minimum of six hours sleep the night before testing, no food within two hours of testing, no smoking within one hour, no liquid intake except water within one hour, no drugs nor alcohol other than beer for 24 hours preceding the test, and no beer within 10 hours, no vigorous exercise on the day of the test, and a room temperature between 68° and 81° Fahrenheit.

The subjects were then classified on the basis of running times, with 20 subjects being in the "Fast" running group and 19 in the "Slow" running group. The division point of 2:40 was selected on the basis of a plotting of running times. The distribution was bimodal, with 18 of the 23 subjects from required physical education having times of 2:40 or slower, and 15 of the 16 subjects drawn from supposedly better conditioned groups having faster times. The

statistical significance of the mean differences were tested for all components. In addition, certain components were divided through by body surface area as obtained from tables based on the DuBois height-weight formula (2) and the significance of mean differences again determined. Cureton (4, *p. 253*) has noted a relationship between body size and wave size.

In Phase II of the study, the groups were enlarged to include all subjects with the division again based on a running time of 2:40, giving a "Fast" group ($N = 29$) and a "Slow" group ($N = 37$). The statistical significance of the mean difference for selected components again was determined.

The grouping in Phase III was on the basis of sports history, the criterion being a minimum of two seasons participation on a varsity team or the equivalent. The groups were termed "Sports" ($N = 31$), and "Non-Sports" ($N = 33$), respectively.

The grouping in Phase IV was on the basis of activity groups at the University of Maryland from which the subjects had been drawn. The groups were termed "Athletic" ($N = 20$), and "Required Physical Education" ($N = 50$).

In all four phases the tracings used, excepting for one case, were those obtained on the first test. In the case mentioned, the subject's first test records were not usable, making a second test necessary.

*Statistical Procedure.* The *t-ratio* was used to determine the statistical significance of mean differences between groups. Homogeneity of variances for the groups was tested using the *F-ratio.* Reliabilities were determined using the rank difference method of correlation and the corresponding coefficient of correlation was estimated by use of a table (11, *p. 165*).

**Results of the Study**

The results of the study are presented in Tables 1 through 6, with each table accompanied by a brief explanation. It is noted that the total number of subjects reported in certain tables does not equal the total number of subjects tested. The operator, in a few instances, failed to disconnect the heartometer from the mercury column and, consequently, the waves were distinctly reduced in amplitude. These recordings could not justifiably be used.

A. *Phase I.* The results of the analysis of the data for the groups selected on the basis of controlled test conditions (Table 1) were: (1) The systolic amplitude and diastolic amplitude of waves obtained with subjects in the lying, sitting, and standing positions had mean differences significant at the five per cent level of confidence.

(2) Systolic amplitude/body surface area-sitting, systolic amplitude/body surface area-standing, diastolic amplitude/body surface area-standing had mean differences significant at the one per cent level of confidence. Lying records were at this point omitted from the analysis. Standing records were used since their *t-ratios* approached the one-per-cent level of confidence, and sitting records were used since all previous work had employed this position.

(3) The mean differences in pulse rates, although not statistically significant, were in the direction commonly associated with differences in good and poor cardiovascular condition.

TABLE 1

*Significance of the Differences Between the Means of the Fast and Slow Running Groups*

| Component | Body-position | Fast group ($N = 20$) | | Slow group ($N = 19$) | | Significant $F$-ratio (5% level) | $t$-ratio | $t$-ratio confidence level (%) |
|---|---|---|---|---|---|---|---|---|
| | | Mean (cms.) | $\tilde{\sigma}^2$ (cms.) | Mean (cms.) | $\tilde{\sigma}^2$ (cms.) | | | |
| Sys. amp. | Lying | 1.909 | .163 | 1.663 | .065 | — | 2.30 | 5 |
| Sys. amp. | Sitting | 1.754 | .190 | 1.505 | .073 | — | 2.15 | 5 |
| Sys. amp. | Standing | 1.510 | .143 | 1.237 | .067 | — | 2.65 | 5 |
| Sys. amp. | Lying-sitting | −.155 | .019 | −.158 | .033 | — | 0.06 | — |
| Sys. amp. | Lying-standing | −.400 | .042 | −.426 | .060 | — | 0.36 | — |
| Sys. amp. | Sitting-standing | −.244 | .032 | −.268 | .039 | — | 0.40 | — |
| Dia. amp. | Lying | .862 | .056 | .722 | .022 | — | 2.26 | 5 |
| Dia. amp. | Sitting | .920 | .048 | .783 | .033 | — | 2.12 | 5 |
| Dia. amp. | Standing | .772 | .052 | .603 | .028 | — | 2.64 | 5 |
| Dia. amp. | Lying-sitting | .058 | .033 | .061 | .018 | — | 0.08 | — |
| Dia. amp. | Lying-standing | −.090 | .056 | −.118 | .038 | — | 0.41 | — |
| Dia. amp. | Sitting-standing | −.148 | .012 | −.179 | .024 | — | 0.70 | — |
| Pulse rate | Lying | 61.6 | 106.8 | 64.8 | 62.1 | — | 1.09 | — |
| Pulse rate | Sitting | 67.0 | 144.5 | 71.2 | 106.5 | — | 1.17 | — |
| Pulse rate | Standing | 76.1 | 167.2 | 84.2 | 256.2 | — | 1.73 | — |
| Pulse rate | Lying-sitting | 5.4 | 19.2 | 6.3 | 61.0 | Yes | 0.44 | — |
| Pulse rate | Lying-standing | 14.6 | 26.7 | 19.4 | 193.0 | Yes | 1.42 | — |
| Pulse rate | Sitting-standing | 9.1 | 28.4 | 13.1 | 66.1 | — | 1.81 | — |
| | | Cms./sq.m. | Cms./sq.m. | Cms./sq.m. | Cms./sq.m. | | | |
| Sys. amp./body surf. area | Sitting | .953 | .041 | .792 | .020 | — | 2.88 | 1 |
| Sys. amp./body surf. area | Standing | .822 | .033 | .649 | .016 | — | 3.47 | 1 |
| Dia. amp./body surf. area | Sitting | .502 | .013 | .412 | .010 | — | 2.65 | 5 |
| Dia. amp./body surf. area | Standing | .421 | .014 | .316 | .007 | — | 3.27 | 1 |

(4) Items based upon postural effects did not demonstrate statistically significant mean differences.

B. *Phase II.* Analysis of the data for groupings based on the 880-yard running times with all subjects included in the groupings provided *t-ratios* which did not differ significantly from those obtained in Phase I where the groups were smaller and composed of subjects tested under relatively controlled conditions (Table 2).

TABLE 2

*Significance of the Differences Between the Means of the Fast and Slow Running Groups, Using an Enlarged Sample*

| Component | Body position | Fast group ($N = 29$) | | Slow group ($N = 37$) | | Significant $F$-ratio (5% level) | $t$-ratio | $t$ ratio confidence level (%) |
|---|---|---|---|---|---|---|---|---|
| | | Mean (cms./sq.m.) | $\tilde{\sigma}^2$ (cms./sq.m.) | Mean (cms./sq.m.) | $\tilde{\sigma}^2$ (cms./sq.m.) | | | |
| Sys. amp./body surf. area | Sitting | .916 | .046 | .799 | .021 | Yes | 2.52 | 5 |
| Sys. amp./body surf. area | Standing | .810 | .036 | .664 | .023 | — | 3.39 | 1 |
| Dia. amp./body surf. area | Sitting | .483 | .015 | .410 | .008 | — | 2.70 | 1 |
| Dia. amp./body surf. area | Standing | .417 | .015 | .324 | .010 | — | 3.34 | 1 |

C. *Phase III.* In this phase of the study, only systolic amplitude being considered, the mean differences between groups formulated on the basis of previous sports activity were significant at the five-per-cent level of confidence (Table 3). Systolic amplitude was selected for analysis in preference to diastolic amplitude, since the *t-ratios* for the two components in Phase I and II were approximately equivalent, and since it is more suitable for routine use being considerably easier to measure.

TABLE 3

*Significance of the Differences Between the Means of the Sports and Non-Sports Groups, as Determined from Sports History Questionnaires*

| Component | Body position | Sports group | | | Non-sports group | | | Significant $F$-ratio 5% level | $t$-ratio | $t$-ratio confidence level (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $N$ | Mean (cms./sq.m.) | $\tilde{\sigma}^2$ (cms./sq.m.) | $N$ | Mean (cms./sq.m.) | $\tilde{\sigma}^2$ (cms./sq.m.) | | | |
| Sys. amp./body surf. area | Sitting | 30 | .923 | .041 | 30 | .808 | .021 | — | 2.52 | 5 |
| Sys. amp./body surf. area | Standing | 31 | .791 | .039 | 30 | .695 | .022 | — | 2.16 | 5 |

TABLE 4

*Significance of the Differences Between the Means of the Athletic and Required Physical Education Groups*

| Component | Body position | Athletic group | | | Required P.E. group | | | Significant $F$-ratio 5% level | $t$-ratio | $t$-ratio confidence level (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $N$ | Mean (cms./sq.m.) | $\tilde{\sigma}^2$ (cms./sq.m.) | $N$ | Mean (cms./sq.m.) | $\tilde{\sigma}^2$ (cms./sq.m.) | | | |
| Sys. amp./body surf. area | Sitting | 20 | 1.004 | .037 | 46 | .784 | .020 | — | 4.58 | 1 |
| Sys. amp./body surf. area | Standing | 20 | .873 | .035 | 46 | .666 | .020 | — | 4.46 | 1 |

D. *Phase IV.* Grouping on the basis of current sports activity at the University of Maryland gave the highest *t-ratios* for any of the three criteria used (Table 4).

E. *Effects of Posture.* The effects of posture on the various components (Table 5) were: (1) The over-all amplitude of the wave (systolic amplitude) decreased as the subject changed from the lying to the sitting to the standing positions.

(2) Diastolic amplitude decreased from the sitting to the standing position and demonstrated a definite trend to do so from the lying to the standing position.

(3) Pulse rate, as would be expected, increased as the subjects moved from the lying to the sitting to the standing positions.

TABLE 5

*The Effects of Posture on the Various Components*

| Component | Body position | Group | Mean difference | Significant *F*-ratio 5% level | *t*-ratio | *t*-ratio confidence level (%) |
|---|---|---|---|---|---|---|
| Systolic amp. | Lying to sitting | Fast | −.155* | — | 5.03 | 1 |
| Systolic amp. | Lying to sitting | Slow | −.158 | — | 3.83 | 1 |
| Systolic amp. | Lying to standing | Fast | −.400 | — | 8.70 | 1 |
| Systolic amp. | Lying to standing | Slow | −.426 | — | 7.65 | 1 |
| Systolic amp. | Sitting to standing | Fast | −.244 | — | 6.12 | 1 |
| Systolic amp. | Sitting to standing | Slow | −.268 | — | 6.00 | 1 |
| Diastolic amp. | Lying to sitting | Fast | .058 | — | 1.44 | — |
| Diastolic amp. | Lying to sitting | Slow | .061 | — | 1.97 | — |
| Diastolic amp. | Lying to standing | Fast | −.090 | — | 1.70 | — |
| Diastolic amp. | Lying to standing | Slow | −.118 | — | 2.64 | 5 |
| Diastolic amp. | Sitting to standing | Fast | −.148 | — | 6.02 | 1 |
| Diastolic amp. | Sitting to standing | Slow | −.179 | — | 4.96 | 1 |
| Pulse rate | Lying to sitting | Fast | 5.4 | — | 5.56 | 1 |
| Pulse rate | Lying to sitting | Slow | 6.3 | — | 3.53 | 1 |
| Pulse rate | Lying to standing | Fast | 14.6 | — | 12.65 | 1 |
| Pulse rate | Lying to standing | Slow | 19.4 | Yes | 6.08 | 1 |
| Pulse rate | Sitting to standing | Fast | 9.1 | — | 7.65 | 1 |
| Pulse rate | Sitting to standing | Slow | 13.1 | — | 7.01 | 1 |

* NOTE: Negative signs indicate that the mean value for the second body position is lower than for the first position.

F. *Reliability.* The reliabilities for the pulse tracings were computed for sitting records only. Reference to Table 6 reveals that the coefficients obtained are considerably lower than those reported by Cureton (3, *p. 268*) and Willett (14).

TABLE 6

*Group Retest Reliabilities Based on Sitting Records as Compared with the Reliabilities Reported by Willett and Cureton*

| Component | This study | *N* | Willett | *N* | Cureton | *N* |
|---|---|---|---|---|---|---|
| Diastolic amplitude | 0.63 | 17 | 0.82 | 69 | 0.77 | 48 |
| Systolic amplitude | 0.76 | 17 | 0.88 | 69 | 0.91 | 97 |
| Pulse rate | 0.50 | 17 | 0.93 | 69 | 0.996 | 97 |

**Discussion of Results**

The results of the study indicate a definite relationship between pulse wave amplitude and the kind of cardiovascular condition associated with the trained state and endurance running performance. There was very little chance of any extraneous factors causing the differences found. The select groups, Phase I, were well equated with respect to most factors assumed to affect circulatory status. The groups were not only well equated with respect to the test conditions listed in the procedure, but also with regard to time of day for testing, season of the year, age, and body surface area. The only factor that might have caused bias was that of vigorous exercise on the previous day. The athletes in the sample, supposedly "tapering off" from competition, were still running each day. In the "Fast" group, 15 of the 20 subjects participated in what might be considered vigorous activities, while in the "Slow" group 7 of 19 exercised vigorously. In the "Athletic" group 15 of the 20 subjects exercised vigorously the preceding day, while 20 out of 50 in the "Required Physical Education" group had so exercised. Cureton (4, *pp. 234–35*) in a single case study observed that upon one occasion, when the subject rested two days before the circulatory tests, diastolic blood pressure and pulse rate were lower and the pulse waves larger than they were on previous occasions, when the subject had exercised the day before.

If this phenonmenon observed by Cureton is real, the effect in the present study would have been to decrease the differences between groups. On the other hand, the writers, studying the effects of distance running on a single individual over a three-month period, gained the impression that physical activity on the preceding day increased the amplitude of the waves (unpublished project). Owing to the conflicting impressions, it seems unlikely that the results of this study were materially affected by this factor. It has been mentioned in order that the findings of this study may be properly interpreted in the event that further research should reveal the presence of such an influence.

The increase in *t-ratios* as a result of dividing the components by body surface area was in agreement with Cureton's findings (4, *p. 253*). This was to be expected with these data, since mean body surface area for the "Slow" group ($N = 19$) was 1.90 square meters, while that for the "Fast" group ($N = 20$) was 1.83 square meters. In addition, in these two groups ($N = 19$ and $N = 20$), body surface area and systolic amplitude for sitting records gave rho's of 0.58 and 0.11 respectively. In a previous unpublished project, carried out by Massey, using 18 subjects, a rho of 0.38 was obtained for the same variables.

The decrease in systolic amplitude with changes from lying-sitting-standing positions parallels what is known about the stroke output of the heart (7, 13). The fact that diastolic amplitude did not follow the same pattern possibly was due to the mechanical properties of the instrument.

That the pulse rate components did not demonstrate significant *t-ratios* should not be considered completely indicative of what would have been found if pulse rates had been obtained by palpation. The emotional factor attending first recordings with the heartometer would tend to keep pulse rates slightly higher than normal.

The reliabilities reported here are lower than those reported by Cureton (3, *p. 268*) and Willett (14). The restricted sample used may have had some effect, but undoubtedly the procedure used was primarily responsible. Willett, for instance, devoted to each subject a much longer initial rest period, not taking a record until he was satisfied that the pulse rate had reached a minimum. In addition, upon retesting, the pulse rate from the second recording was computed immediately, and if the rate was not within four beats per minute of that for the first test, the subject was recalled for a third examination.

**Summary**

A study was undertaken using 70 young male subjects to determine the effect of posture on the brachial sphygmogram as an indicator of the kind of cardiovascular fitness which is associated with the trained state and endurance performance.

The subjects ranged in age from 17 to 27 years, were in sufficiently normal health to participate in required physical education at the University of Maryland, and all were volunteers. The data obtained were pulse tracings with the subjects in the lying, sitting, and standing positions, an 880-yard run time, sports history, height, and weight.

The analysis of the data was carried out by dividing the subjects into groups representing good fitness and poor fitness. This was done in three different ways, using as criteria an 880-yard run, previous participation in competitive sports, and current sports activity at the University of Maryland. The statistical significance of the mean difference between groups was tested by use of the *t-ratio*. In addition, the effects of dividing certain components by body surface area, the effects of postural changes on pulse wave form, the significance of mean differences between groups for measures based on the effects of posture on pulse wave form, and the reliability of the techniques used for recording pulse waves were determined. Pulse rates as computed from the pulse tracings were included in the analysis.

The findings of the study were: (1) The amplitude of both the initial upsurge (systolic amplitude) and dicrotic wave (diastolic amplitude), measured from waves recorded with the subjects lying, sitting, or standing, were significantly greater for a group of individuals drawn from a population in good cardiovascular condition, as indicated by an endurance run, than they were for a group in relatively poor condition. The significance of the mean differences were approximately equivalent, all being at the 5-per-cent level of confidence. Dividing the components for sitting and standing records by body surface area increased the significance of the mean differences.

(2) Pulse wave variables based upon differences in wave contour, resulting from postural effects, did not reflect differences in endurance fitness as indicated by an 880-yard run.

(3) Pulse rates determined from heartograms, recorded in the lying, sitting, and standing positions, and pulse rate differences due to postural effects demonstrated for groups differing in endurance fitness means which differed in the direction commonly associated with good and poor cardiovascular condition, but these differences were not statistically significant.

(4) Systolic amplitude for sitting and standing tracings divided by body surface area demonstrated mean differences significant at the five-per-cent level of confidence when the subjects were grouped according to past sports activity, and mean differences significant at the one-per-cent level of confidence when the subjects were grouped according to sports activity at the University of Maryland. The better conditioned groups in each case had the waves of greater amplitude. The latter method of grouping gave higher *t-ratios* than did the groupings based on running times and past sports activity.

(5) Changes in posture from lying to sitting to standing caused a progressive decrease in the systolic amplitude of the waves and a progressive increase in pulse rate. The diastolic amplitude of waves was lower for the standing posture than it was for the lying and sitting postures.

**Recommendations for Further Study**

(1) Brachial sphygmograms as an indicator of cardiovascular fitness should be compared with more generally accepted cardiovascular tests.

(2) The effects on the form of brachial sphygmograms, of vigorous exercise on the day preceding testing should be investigated.

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# Constructing an Instrument for Evaluating Attitudes Toward Intensive Competition in Team Games[1]

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IT IS RECOGNIZED that many changes are taking place in our culture today. Some of these changes directly affect physical education and athletic programs and imply changes in philosophy. Therefore, it seems the responsibility of physical educators to understand, evaluate, and, as far as possible, to control these changes in line with general education objectives.

## Purpose of the Study

Attitudes toward athletic competition in team games are at present undergoing radical revisions. A first step toward making an appraisal of this reaction to athletic competition is to gain a knowledge of present status. The purpose of this study was to develop a procedure which would make possible an objective and reliable assessment of individual and group attitudes toward intensive competition in team games.

## Procedure

A survey of current attitudes toward intensive competition in team games was made in order to secure a comprehensive sampling of present day ideas. The sources used were current professional and popular literature and individual interviews. Thirty-five persons were interviewed and asked to talk informally on their ideas about competition in team games. Those interviewed represented varied experience and points of view. They included students, instructors, administrators, parents, skilled athletes, coaches, ministers, and doctors. As a result of this survey 145 statements pertaining to intensive competition in team sports were prepared according to the criteria of Wang (3) and Thurstone Chave (2).

On the basis of all available material criteria were then established for classification of the statements into seven areas or special phases. The 145 statements were distributed into the following areas: personality development, 63 items; human relationships, 34 items; public relations, 14 items; physical development, 9 items; skill development, 11 items; recreation, 9 items; and safety, 5 items. The number of items in each division of course reflected the relative importance placed on that grouping as a result of the readings and interviews.

In order to obtain relevant and internally consistent items, the Lickert (1) procedure of presenting the items to a group of respondents was used. Two

[1] This study was done at the State University of Iowa. The writer is indebted to Dr. Elizabeth Halsey and Dr. Harold Bechtoldt for advice and criticism.

judgments were asked of each respondent. First, a judgment was to be made on the favorability or unfavorability expressed by the item. Second, the respondent was requested to state his own personal willingness to accept or reject the item. Both of these procedures allowed for five levels of response. Each judge was instructed to complete all the favorability responses first, and then to give his own opinion on each of the items.

Included in the group of judges were 11 graduate students and 14 from the teaching staff in the Women's Department of Physical Education of the State University of Iowa, and 5 instructors, 5 coaches, and 12 graduate students from the Men's Department of Physical Education of the same institution. For administrative convenience in obtaining responses, two answer sheets were provided, and a repeated sampling of the items from the seven areas was obtained by listing them in the "omnibus cyclic" form. For both sets of responses the instructions emphasized that category C, or neutral, be used only if the respondent was sure he had no opinion on the item.

Responses as to favorability of the items were obtained to insure that all stages of opinion toward intensive competition in team games could be represented. The index of favorability used for classifying the items was the category containing the largest number of responses. Ambiguity, that is, disagreement as to judgment of favorability, was indicated by the spread of answers around the modal value. Criteria set up to exclude ambiguous items called for discarding any items which had a spread of more than 80 per cent on either side of the modal category. On the basis of the criteria set up for ambiguity and because of duplication of items, reduction was made on the number of items from 145 to 77. Items were of course retained to cover the full range of favorability and to cover the seven categories.

An evaluation was made of responses given by the expression of opinion toward the item. A five-point scoring system ranging from plus two to minus two was used with the plus value responses rated as favorable. The individual's score was then weighted by the response value.

Stability or consistency of the individual's attitudes was investigated by administering the final form of the scale to the 25 individuals from the Women's Physical Education Department a second time 10 to 13 weeks after they had stated their first agreement. The product moment correlation for total scores on first and second response was .70. This value is especially interesting in view of the fact that between times of responding to the items a great deal of publicity had been given to discussion of bribery in athletics and also because three-fourths of the individuals had attended conventions where they had opportunity to hear various opinions expressed regarding trends in athletics and physical education.

Evidence of the stability of the evaluation of the 77 items as to their favorability was also obtained by considering the two test administrations. After each item had been assigned a modal score on favorability, estimates of stability for each area were obtained by the rank difference method of correlation.[2]

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[2] The number of tied ranks will affect the magnitude of this coefficient to some extent, but this was not considered.

For five of the areas the values of rank correlation were .82 or above. The personality area, consisting of 29 items, gave a correlation of .82; recreation, with six items, a correlation of .91; skill and physical development, each with six items, both gave a correlation of .93; and public relations, with eight items, gave a correlation of one.

The safety category, with a rank order correlation of .28 on five items, proved to be the most variable set of items. For this reason, the safety items were restudied. The wording of one item was changed and three new items were added. The other low item mode correlation was on human relationships, which had a rank order correlation of .60 on 17 items. Two of the items in this category were reworded as a result of comments received from those who answered the attitude scale. In a future study this slightly revised list of items would be given to a larger group on a test retest basis to further study reliability.

A simplified scoring system was investigated by scoring all responses on a three-point scale of plus one to minus one. A product-moment correlation of this scoring with results obtained from the five-point scale gave a correlation of .93 for total scores. While this correlation indicates that rank orders are not identical, it was felt that the correlation was high enough to warrant the use of the shorter method and thus allow for easy machine scoring of the attitude scale.

## Summary

Such an objective and reliable procedure as has here been established should be useful in studying various socio-economic groups and geographic areas. Experience and education could be used as variables in making studies with this scale. It is also suggested that this scale would, with slight revisions, be applicable to competition in team sports at various age levels.

### Items Pertaining to Intensive Competition in Team Games

*Consider how strongly you personally agree or disagree with the following statements of opinion. Consider each statement in turn and record your opinion using the following code based on letters a through e:*

| *Strongly agree* | *Agree* | *Neutral or Indifferent* | *Disagree* | *Strongly Disagree* |
|---|---|---|---|---|
| a | b | c | d | e |

1. This type of competition generally promotes community spirit.
2. Participation develops physical fitness in most individuals.
3. Participation gives most individuals self-assurance.
4. Winning and losing in this type of participation helps to prepare most individuals for the competition they meet in daily living.
5. Participation helps to train most individuals to face the problems of life.
6. This type of participation enables most individuals to work off emotional tensions.
7. Participation in this type of competition often leads to acceptance of the fact that one must play "rough" if the opponents are rough.
8. The public is so interested in this type of competition that it judges school administrators by the success or failure of their athletic teams.
9. Participation gives most individuals a high sense of self-respect.
10. Participation tends to put most individuals in a state of emotional upset for a long period of time.
11. Participation gives most individuals an appreciation for a job which is well done.

12. The experience of this type of participation develops many individuals as leaders.
13. Most participants learn to respect any individual who has skill, whether opponent or teammate.
14. The excitement of the spectators is an emotional strain for many of the participants in this type of competition.
15. Most high schools cannot afford the equipment necessary to make participation in this type of competition relatively safe for their players.
16. Participation gives most individuals mental relaxation after the pressure of a game is over.
17. After individuals have participated in this type of competition, they are more likely to want to participate in sports for the rest of their lives.
18. Participation gives most individuals a sense of good sportsmanship.
19. The skilled person needs this type of participation in order to stimulate him to develop his physical skill still further.
20. Participation in this type of competition helps to train most individuals to form realistic outlooks and aims.
21. Some coaches will take the chance of playing a player even if previous injury has made it unsafe for him.
22. Participation leads most players to expect better grades than if they were not on the team.
23. Participation gives most players the feeling that they are doing a job for which they should be paid.
24. The ingenuity of most individuals is increased through participation.
25. Participation presents no greater danger of accidents than other phases of daily living.
26. Through participation most individuals gain in mental alertness.
27. Participation makes most people feel that they are accepted by society.
28. Most players have limited opportunity to show initiative in the game situation.
29. Participation in this type of competition gives most individuals an enjoyment of participating in activity.
30. Most participants are happier and better adjusted individuals than non-participants.
31. Participation gives most individuals the ability to be at ease before the public.
32. Participation helps most individuals acquire good manners which carry-over into phases of everyday living.
33. Participation helps most individuals to discover what is needed to improve their own physical skill.
34. Through participation many players learn to evade the rules of the game.
35. This type of competition seldom promotes any interest in all the rest of the school's class program.
36. Participation trains most individuals to profit from criticism.
37. Most individuals are aided in strengthening their ethical code by participation.
38. Most spectators get some enjoyment from humiliating their opponents through overwhelming defeat.
39. Participation often leads to unnecessary injury.
40. Participants tend to value accomplishment only if it is recognized publicly with prizes and similar awards.
41. Participation teaches most individuals to work for what they get.
42. Participation teaches most individuals to win without boasting.
43. This type of participation usually trains one in good health habits.
44. Many spectators of this type of contest do some betting on the outcome of the game.
45. Participation gives many individuals a feeling of inferiority if beaten often.
46. Participation teaches most individuals how to behave in social situations.
47. Many spectators of this type of competition express feelings of antagonism toward the opposing side.
48. Danger of injury is one of the principal drawbacks to this type of activity.
49. Participation teaches most individuals to respect the rights of others.
50. Participation teaches most individuals to carry through in face of hardships.
51. This type of competition generally results in spectator control of sports.
52. This type of competition promotes a desire for greater athletic skill in younger boys who admire the success of well-known players.

53. This type of competition teaches most participants how to build up their own good physical condition.
54. Many participants learn to say they are amateurs although they actually do get large or small financial gains from their playing skill.
55. This type of participation does little toward equipping a person with recreation skills for later life.
56. Participation places an undue amount of physical strain on many individuals.
57. Many people who have entered into this type of competition do not enjoy athletics unless they can play before a crowd.
58. Participation is an effective way to get acquainted with people from other communities.
59. This type of participation enables most individuals to develop reserve physical strength for emergencies.
60. This type of competition seldom helps to promote the whole program of physical education.
61. This type of competition trains most individuals to consider their opponents as their enemies.
62. Participation helps most individuals to set a goal and follow it.
63. Developing the greater strength needed for this type of participation "burns" most individuals out physically after they retire from the activity.
64. Participation teaches most individuals to get along with people in the game situation and in many other aspects of life.
65. Participation gives many individuals an exaggerated idea of the value of their skills.
66. Through participation most individuals learn to control their temper.
67. Most highly skilled individuals get more fun from this participation than from any other type of physical activity.
68. This type of participation stimulates most individuals to give their best possible performance.
69. Most people who reach the skill level necessary for this type of participation are not willing to participate in any other athletics in which they do not already excel.
70. Participation teaches most individuals to be modest.
71. Most participants improve their skill in getting acquainted with strangers.
72. To develop the great degree of athletic skill required by such competition takes more time than most students can afford to spare.
73. Participation trains most individuals to make quick decisions and responses when movement is called for.
74. This type of competition often causes a disregard for the rules of the game.
75. Many participants of this type of competition express feelings of antagonism toward the opposing side.
76. Participation helps to train most individuals in accepting the rule of the majority.
77. Many players get some enjoyment from humiliating their opponents through overwhelming defeat.

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# Kinesthesis in Relation to the Learning of Selected Motor Skills[1]

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RECOGNITION OF the importance of the kinesthetic sense in teaching physical education is not new. The presence of kinesthetic sense has often been considered one of the factors contributing to the ability of an individual to learn an activity or a skill. Many writers have said that the higher the level of the kinesthetic sense possessed by an individual, the greater his ability to learn skills. However, only a few physical education studies have attempted to measure kinesthetic sense.

One of the recent research studies directed toward the determination of a battery of tests which would measure kinesthesis was carried on at the State University of Iowa during the year 1950–1951 (3). In this study 12 tests of kinesthesis were administered to 104 college women. Three of these tests were recommended by Young (5) as a battery of tests for use in further research. They have been called Arm Raising, Leg Raising, and Balance Stick. One additional test, Pointing to a Target, was suggested by Fisher (1). The "Victory Through Fitness" workshop (4) suggested Walking on a Path, Pointing to a Target, and Throwing at a Target. The Balance Stick test and another test of balance, Balance Leap, have been described previously by Scott (2). Tests which were constructed for the above study have been called Floor Target, Weight Shifting, Arm Circling, Arm Swinging, and Dynanometer Grip.

### Statement of the Problem

The purpose of this study was two-fold: (1) to continue the development of a battery of tests measuring kinesthesis, and (2) to investigate the relationship, if any, between kinesthesis and the learning rate of college women in certain motor skills.

### Procedure

Eight of the tests used in the Scott research project (3) were selected for this study. The tests were selected on the basis of their reliabilities and validities. Those tests were the following: Balance Stick, Arm Raising, Leg Raising, Balance Leap, Floor Target, Weight Shifting, Arm Circling, and Arm Swinging.

During the first semester of the academic year 1951–52, these eight tests were administered to 200 college women, students in physical education classes at the State University of Iowa. Sixty-four of the subjects were selected because they were enrolled during the fall term in skills clinic classes. These skills clinic

[1] This study is based on a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Physical Education in the Graduate College of the State University of Iowa, 1952.

classes are organized for those students who rank in the lower quartile on the Scott Motor Ability Test (2). Twenty-two students enrolled in a tennis class taught by the writer were given the eight tests. In order to have the entire group of subjects used in this study approximate a normally distributed group of college women, 50 subjects were selected who ranked in the upper quartile on the motor ability test. During the second term of the first semester, all women students enrolled in bowling classes were given the tests of kinesthesis if they had not been previously tested. This made a total of 200 subjects whose mean motor ability *T*-score was 50.46.

Reliabilities were found for four of the tests: Balance Stick, Arm Raising, Leg Raising, and Balance Leap. These reliabilities were computed by the odd-even method and were stepped up by using the Spearman-Brown Prophecy Formula. The reliabilities for the other four tests were assumed comparable to those found in the Scott study (3).

Validities were computed on each of the tests using the total *T*-score on all eight tests as the criterion. A battery of tests was selected by means of the Doolittle method of computing multiple correlations from intercorrelations, and a regression equation was determined. The regression equation was used to compute a kinesthesis score for each subject.

Four skills clinic classes were used in an experimental study. Two instructors each taught two classes, one by an experimental method and one as a control class. The experimental classes were taught by methods attempting to stress a kinesthetic approach. A committee of the two instructors of skills clinic classes, the chairman of the skills clinic committee, and the writer met weekly to plan lessons stressing a kinesthetic approach for the experimental classes. These skills clinic classes at the State University of Iowa have been planned for and required of students whose scores on the Scott Motor Ability Tests were in the lower quartile. The background of these students has shown very little experience in physical education activities and thus the fundamental skills of walking, running, jumping, striking, and throwing have needed to be stressed. In addition, the students have been taught volleyball.

In general, the methods used in the experimental classes differed from the methods used in the control classes by the addition of the following procedures:

The "feel" of a movement was stressed in all skills.

More short demonstrations were presented, especially after the students had attempted the skills.

Before a demonstration the students were asked to try to feel themselves performing the skill as they watched.

More visual aids were used than had been used previously. Four short films on running, jumping, striking, and throwing were shown immediately after the class had practiced that particular skill. The students were asked to try to feel themselves performing the skill while watching the film. Immediately after each film the class returned to practice on that particular skill. Each of the four films was shown twice during the term.

Drills were used in which the students closed their eyes, omitting the presence of visual sensations.

Practice on the balance beams was added, both with the eyes open and closed.

The experimental plans did not involve any drastic changes or new techniques but they simply changed the emphasis.

The kinesthesis tests were given to all skills clinic students early in the term and again at the end of the eight weeks of instruction. The motor ability test was also repeated during the last week of the course. This made it possible to compute the gains of each student on both the motor ability test and the kinesthesis test. All girls were also given a volleyball performance test.

During the fall term, one tennis class of 22 students was taught by methods attempting to stress the feel of each stroke. These students were given the tests of kinesthesis, and motor ability *T*-scores were available for them. At the end of the eight-week term they were rated by three experienced judges on their form on three strokes—the forehand drive, backhand drive, and service. At the same time they scored on a wallboard test described by Scott (2).

For the bowling classes, a procedure similar to that for the skills clinic classes was carried out. There were three different instructors for four bowling classes during the second term of the first semester. The one instructor who had the two classes was one of the skills clinic instructors and again she taught one class by an experimental method and one as a control class. The one class taught by the writer was selected as a second experimental class and the class taught by the third instructor was used as a control class.

All classes met twice a week for 90-minute periods at public alleys in Iowa City. The students set their own pins. Usually there were four students on one alley. The term lasted for eight weeks.

There were 41 students in control classes and 39 students in the experimental classes. The departmental bowling committee and the three bowling instructors met twice to suggest methods of teaching the experimental classes which would stress the kinesthetic approach. The two instructors of the experimental classes met weekly to work out their methods of teaching.

In order to have some measure of the status of the students in bowling before their class instruction, all four classes kept score for one line on their second day at the bowling alleys. Although these scores were used to indicate initial ability, it was recognized that the score on just one bowling line is not very reliable. Since scores tend to fluctuate very much, a score for one line was recorded on each of the last four days of the class and the mean of these last four scores was used as the final performance score for each student.

The kinesthesis tests were given to all bowling students and the motor ability test was given to those students for whom no score was available.

**Analysis of Data**

The motor ability *T*-scores of the 200 subjects who were given the eight tests of kinesthesis ranged from 18 to 84, the mean was 50.46, and the standard deviation 12.36. For the purposes of this study, the sample was assumed to be a random sample of women students in the State University of Iowa.

The different types of tests of kinesthesis and the different units of scoring made for unequal variability among the tests. The Arm Circling and Arm Swinging tests were scored on a nine-point rating scale and both distributions were skewed to the right. The scores on the other tests were more normally distributed.

The reliability and validity of each test as determined in the 1950–51 Scott (3) study and those found in this study are shown in Table 1. The four reliability coefficients determined in this study were found by correlating the odd-numbered trials with the even-numbered trials and stepped-up for the total number of trials by the Spearman-Brown Prophecy Formula. The reliability obtained for the Balance Leap test was much lower than that found in the previous study and in several other unpublished studies by Scott. On the basis of previous results, the test was retained for consideration in the selection of a battery of tests.

TABLE 1
*The Reliability and Validity of Each Test*

| Test | Reliability | | | | Validity | |
|---|---|---|---|---|---|---|
| | 1950–1951 | | 1951–1952 | | 1950–1951 | 1951–1952 |
| | O-E | S-B | O-E | S-B | | |
| Balance Stick | .56 | .72 | .76 | .86 | .42 | .55 |
| Arm Raising | .67 | .80 | .67 | .80 | .44 | .50 |
| Leg Raising | .97 | .98 | .89 | .94 | .27 | .39 |
| Balance Leap | .70 | .82 | .48 | .65 | .61 | .55 |
| Floor Target | .73 | | | | .39 | .33 |
| Weight Shifting | .68 | | | | .30 | .43 |
| Arm Circling | .64 | | | | .58 | .56 |
| Arm Swinging | .78 | | | | .58 | .53 |

O-E—odd-even reliability coefficient.
S-B—stepped-up by Spearman Brown Prophecy Formula.

The raw scores on each test were converted to *T*-scores and the sum of the eight *T*-scores was used as the criterion in computing the validity of each test. The validity coefficients showed much similarity to those of the previous study and all tests were considered in the determination of a battery of tests.

The intercorrelations of the kinesthesis tests are shown in Table 2. The high intercorrelation between the two arm exercises, Arm Circling and Arm Swinging, was expected and also the high relationship between the two balance tests. However, there was no obvious explanation for the apparent correlation between either of the balance tests with Arm Swinging.

A multiple correlation coefficient was computed for a number of test combinations. One of the four-item combinations was selected for use in this study since

TABLE 2
*The Intercorrelations of Each Test*

| Test | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| 1. Balance Stick | .15 | .14 | .32 | .05 | .17 | .10 | .32 |
| 2. Arm Raising | | .08 | .20 | .15 | .04 | .22 | .17 |
| 3. Leg Raising | | | .04 | −.01 | .08 | .09 | .19 |
| 4. Balance Leap | | | | .05 | .12 | .14 | .26 |
| 5. Floor Target | | | | | .04 | .07 | .06 |
| 6. Weight Shifting | | | | | | .16 | .06 |
| 7. Arm Circling | | | | | | | .33 |
| 8. Arm Swinging | | | | | | | |

none of the three-item batteries was considered satisfactory and no five-item battery was found to be enough better to warrant the additional test item. The coefficient of multiple correlation for this battery was .88. The following regression equation was computed:

.75 Balance Stick − Arm Raising − Weight Shifting + 4.7 Arm Circling + 50

All of the regression coefficients were positive but in both Arm Raising and Weight Shifting the lower the raw score the better the performance. A description of these four tests is given in the Appendix.

The regression equation was used to compute a kinesthesis score for each subject and the scores ranged from 6 to 170 with a mean of 77.8 and standard deviation of 29.66. These kinesthesis scores were correlated with the motor ability *T*-scores and the resulting coefficient was 0.42. This correlation is significant at better than the 1-percent level of confidence.

In Table 3 the skills clinic control and experimental groups are compared. The two groups were considered comparable on the basis of initial ability. None of the differences was significant. Although the mean of the gains in motor ability was higher for the control group than for the experimental group, much of this difference can be attributed to one class which met four times a week for a single period while the other three classes met twice a week for a double period. The mean of the gains in kinesthesis scores, on the other hand, was greater for the experimental group but with such a large variability in the scores, the difference was not significant. The gains in kinesthesis did show that it was possible to raise the level of the kinesthetic sense possessed by an individual, as measured by these tests.

The correlation between the tennis performance scores for 22 subjects and their motor ability scores was .44 and this value is significant at the 5-percent level of confidence. No significant correlation was found between tennis performance and kinesthesis.

TABLE 3

*Comparison of Skills Clinic Control and Experimental Groups*

| Group | n | Range | Mean | S.D. | t |
|---|---|---|---|---|---|
| Initial motor ability *T*-score | | | | | |
| Control group | 29 | 18–44 | 36.55 | 5.35 | |
| Experimental group | 35 | 25–44 | 38.80 | 4.72 | 1.840 |
| Initial kinesthesis score | | | | | |
| Control group | 29 | 6–95 | 60.76 | 23.34 | |
| Experimental group | 35 | 13–99 | 60.58 | 19.86 | 0.033 |
| Gains in motor ability | | | | | |
| Control group | 29 | 0–20 | 10.62 | 5.07 | |
| Experimental group | 35 | −3–17 | 8.29 | 4.21 | 1.970 |
| Gains in kinesthesis | | | | | |
| Control group | 29 | −8–70 | 32.95 | 20.40 | |
| Experimental group | 35 | 0–84 | 42.00 | 21.70 | 1.679 |
| Volleyball scores | | | | | |
| Control group | 29 | 43–96 | 75.51 | 13.83 | |
| Experimental group | 35 | 52–100 | 80.05 | 10.80 | 1.423 |

NOTE: t for 5% is 2.000. None of the differences were significant.

Table 4 compares the bowling control and experimental groups. The groups were considered as comparable on the basis of initial ability in bowling, motor ability, and kinesthesis. The two groups were very similar in their final averages of four bowling lines. The experimental group showed more improvement in bowling than the control group but the difference in their gains was not significant.

The correlation found between the gains made by the 80 bowling students and their first scores resulted in a correlation coefficient of −.76. This indicated that those who were low on their initial score had a better chance for improvement than those who started with a higher score. No correlation was found between either motor ability or kinesthesis and final bowling scores, and no correlation was found between either motor ability or kinesthesis and gains in bowling scores.

TABLE 4

*Comparison of Bowling Control and Experimental Groups*

| Group | n | Range | Mean | S.D. | t |
|---|---|---|---|---|---|
| Motor ability *T*-scores | | | | | |
| Control group | 41 | 33–70 | 54.05 | 9.41 | |
| Experimental group | 39 | 37–84 | 53.28 | 9.91 | 0.353 |
| Kinesthesis scores | | | | | |
| Control group | 41 | 20–146 | 85.38 | 27.34 | |
| Experimental group | 39 | 14–144 | 82.30 | 32.54 | 0.454 |
| First bowling score | | | | | |
| Control group | 41 | 36–123 | 86.66 | 19.95 | |
| Experimental group | 39 | 52–118 | 80.80 | 17.60 | 1.372 |
| Average of last four bowling scores | | | | | |
| Control group | 41 | 69–136 | 104.58 | 13.42 | |
| Experimental group | 39 | 75–133 | 102.38 | 12.28 | 0.781 |
| Gains in bowling scores | | | | | |
| Control group | 41 | (−17)–67 | 16.38 | 16.47 | |
| Experimental group | 39 | ( −9)–65 | 22.40 | 16.42 | 1.618 |

NOTE: t for 5% is 1.991. None of the differences were significant.

## Conclusions

1. The eight tests of kinesthesis used in this study all have merit for use in other studies working on a battery of tests to measure kinesthesis.

2. The following battery of tests can be recommended as a measure of kinesthesis in college women:

.75 Balance Stick−Arm Raising−Weight Shifting + 4.7 Arm Circling + 50

3. There is a positive relationship between motor ability as measured by the Scott (2) test and kinesthesis as measured by this test.

4. There is no statistically significant evidence that the experimental methods of teaching used in this study are better than those used in the control classes.

5. The lower the initial bowling score of a student, the better are her chances for improvement in bowling.

## APPENDIX

### DESCRIPTION OF KINESTHESIS TESTS

#### *Balance Stick*

A stick which is one inch square and twelve inches long is securely taped to the floor with adhesive tape. The subject is given the following verbal directions:

> Stand with your foot lengthwise on the stick. When your foot is secure, close your eyes and lift the other foot off the floor and hold your balance as long as possible. You may do anything you like as long as you do not open your eyes or touch the floor with any part of your body. You will be timed from the moment you lift your foot from the floor until you open your eyes or touch the floor. You may have one practice with your right foot and then three test trials, and then one practice with your left foot and three test trials. Then, there will be three more trials on each foot. Your score will be the total time on 12 trials.

One demonstration is given while giving instructions. The subject is timed from the moment she lifts her foot until she opens her eyes or touches the floor. There are 12 trials which make up the total score: three right, three left, three right, and three left. The total score is recorded in seconds.

#### *Arm Raising*

The subject is given the following verbal instruction:

> Raise your right arm out sideward to a horizontal position with the palm facing down.

The instructor faces the subject and uses a goniometer to determine how far the subject has deviated in raising her arm to the horizontal. A line from the shoulder joint to the base of the thumb should be parallel with the floor. The deviation is recorded as degrees of deviation from the horizontal. The arm is lowered and the test is repeated. Then the test is given twice using the left arm. The total score is the sum of deviations on the four trials and is recorded in degrees. A score of zero is a perfect score.

#### *Weight Shifting*

The equipment for this test consists of a bathroom scale and a block of wood one foot long and half a foot wide. The thickness of the block is that which will make the block the same height as that of the scale platform. The block is placed next to the scale so that they are side by side, with the block on the left side. The subject places her left foot on the block and the right foot on the scale. One demonstration is made while the following verbal instructions are given:

> Stand on the scale so I can determine your weight. Then put your left foot on this block of wood and place just enough weight on your right foot to run the scale up to ———pounds. You may have two practices to run the scale up to———pounds and then you will be asked to start with the scale at zero, look away and try to run the scale up to the same weight. As you see, it is hard to hold the scale steadily so you will have to say "Now" when you think you have the scale where you want it.

The subject is told to place one-half of her weight on the scale, but is not told that the required wieght is one-half of her own weight. The test is repeated on the other side of the scale with the left foot on the scale. The score on the test is the sum of the deviations of the right foot and the left foot from the required weight, one-half of the subject's weight. The score is given in pounds. A perfect score is zero.

#### *Arm Circling*

The instructor gives one demonstration of this test while giving the following verbal instructions:

> Try to circle your arms in complete circles but in opposite directions so that one arm makes a complete circle going forward while the other arm makes a complete circle going backward. It will look like this.

The subject is not allowed to do the exercise with the instructor. The instructor rates the subject on her performance using the following 9-point scale in which each attempt to do the exercise is considered as a trial:

*Rating Scale for Arm Circling Test:*

9—Performed in good form on first attempt.
8—Performed in good form on second attempt.
7—Performed in fair form on second attempt.
6—Performed in fair form on third attempt.
A second demonstration is given if the subject has not performed the exercise after three attempts.
5—Performed in good form on fourth attempt.
4—Performed in fair form on fifth attempt.
3—Performed in poor form on sixth attempt.
2—Performed in poor form on seventh attempt.
1—Subject unable to perform exercise in seven attempts.

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# The Differential Effects of the Development of Athletic Ability of a High Order[1]

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THIS STUDY WAS designed to investigate certain aspects of high-order athletic talent. This talent has become both a respected and a remunerative one in our society. However, it has seldom been the subject of intensive investigation. For example, very little evidence could be found in the experimental literature as to the exact nature of athletic talent.

The reports which could be found in this area generally indicated the following:

1. Athletic ability involves more than just motor ability. Although it is difficult to isolate the other factors involved, what evidence there is indicates the presence of such qualities as perseverance, ambition, and courage.
2. The components in athletic ability are specific for different individuals and for different activities.

**Nature of the Study**

Basically, this study was aimed at determining the present adult status of a group who had at one time shown evidence of unusual athletic talent. It was conducted as a comparative analysis of two groups of college graduates, all of whom graduated in 1932, 1934, 1936, or 1938 from one of the following four schools or colleges of the University of Minnesota: Science, Literature, and the Arts; Business; Technology; and Education. One of these two groups (called the "experimental" group in this report) consisted of all men who had earned an athletic letter during the years indicated—the "M" men. The other group (called the "control" group) consisted of men who had not earned a letter, but it was so selected by stratified sampling procedure as to be comparable to the first group with respect to year graduated and college from which graduated.

The study attempted to determine which (if any) of a number of factors would operate to differentiate the present adult status of the two groups. These factors were principally in the following areas: occupational and economic status; health; leisure activities; opinions on social, political, and economic issues; civic activities; and military service. Comparisons were also made on educational background and other aspects of collegiate life, and on a number of miscellaneous factors. The bulk of the information in these areas was secured

[1] This study was made in partial fulfilment of the requirements for a Doctor's degree at the University of Minnesota under the direction of Dr. Carl L. Nordly. The complete dissertation is available on microcards, made at Springfield College, Springfield, Massachusetts, under the direction of Dr. H. Harrison Clarke.

through the medium of a seven-page questionnaire, mailed to the selected subjects. Some additional information was secured from college records.

Originally, 116 "M" men comprised the experimental group, and 409 nonletter winners the control group—a total of 525. Of these, 118 could not be contacted, either because no addresses could be found, or because the addresses turned out to be inaccurate. Of the remaining 407, 319—about 78 per cent—responded in time to be included in the analysis. These respondents were found to be comparable to the original 525 with respect to year graduated, college from which graduated, and collegiate scholarship. However, the respondents consisted of a significantly greater proportion of "M" men than did the original group of 525.

**Procedures**

Most of the data in this study were in the form of frequencies within certain categories. Usually, the null hypothesis under test was that there was no difference between the experimental and control groups with respect to some characteristic. Therefore, Chi Square analysis was the most commonly used statistical tool throughout the study. When statements as to significance or difference are made in this report, it can be assumed that significance was determined by this procedure, unless otherwise stated. Other investigational devices are presented in context.

**Findings**

Because of the nature of the investigation, evidence was discovered in relation to nearly 200 separate items of information. Presented below are those findings which served to differentiate the experimental group from the control group. Also included are some of the especially pertinent similarities which were discovered. For all of these items, evidence is available for the respondents as a whole; however, this is not presented here. The findings given here are presented under headings indicating the major divisions of the study.

*Educational background.* Measures of both scholastic aptitude (percentile scores of the College Aptitude Test) and scholastic achievement (honor point ratio) were available for 366 of the original 525 subjects. In order to determine whether the experimental and control groups differed in scholastic achievement, both in itself, as well as when the effect of scholastic aptitude was held constant, analysis of variance and covariance was used to compare the two groups in these respects. Because neither of the variables satisfied the criterion of normality which is basic to the use of this technique, both variables were normalized by transformation into standard score units, with the mean set at 60, and unit standard deviation set at 20.

On the basis of an analysis of these transformed scores, the experimental and control groups did not differ significantly as to scholastic achievement itself, nor when the effect of aptitude was held constant. Similar comparisons were made for the two groups of graduates from each of the four colleges involved in this study. It was found that while the differences in scholastic achievement favored the experimental group in two colleges and the control group in the

other two, the difference was significant only in the case of graduates from the College of Education. Here, the control group was significantly superior to the experimental group in scholarship itself, as well as when the effect of aptitude was held constant.

Other findings in relation to educational background included:

1. The experimental group participated significantly more in extracurricular activities in general, and also exercised more leadership in these activities.

2. Although the groups did not differ in the generally high value they placed on college education, the experimental group valued more highly participation in extracurricular activities.

3. The two groups did not differ in college from which graduated, year graduated, proportion of advanced degrees obtained, and extent to which vocational objectives were changed after entering college.

*Occupational status.* Significant differences between the groups in this area included:

1. The groups differed in their over-all distribution according to present jobs. Principally, more of the experimental group were in the business fields. About the same differences were noted in relation to first jobs after graduation from college.

2. The experimental group placed a higher value on the vocational advantages of collegiate extracurricular participation. However, this difference was resident primarily in the graduates from the College of Education.

3. The median income of the experimental group during 1947 was $5,714, and for the control group, $4,354, a highly significant difference. The difference was also significantly in favor of the experimental group within three of the four colleges, being non-significant only for the graduates from the Institute of Technology.

4. The groups were similar with respect to methods used to obtain first and present jobs, opinion as to vocational advantages of college education, degree of vocational stability, and job satisfaction.

*Health.* The experimental and control groups did not differ in their evaluation of their own health status. Neither did they differ in most of the health practices which were investigated, the only difference here being that more of the experimental group took definite physical exercise regularly.

*Leisure activities.* In relation to leisure activities, the differences discovered between the two groups were about what might be expected in view of the initial criterion differentiating the groups. In general:

1. The experimental group indicated a greater relative participation in all activities of an athletic nature, either as an active participant or as a spectator. This group also participated significantly less in aesthetic activities.

2. About the same general differences were noted with respect to how well the members of these two groups liked the various activities.

3. No significant group differences were found with respect to the rest of the 30 leisure activities listed in the questionnaire. Also, the correlation between "frequency of participation" and "degree of liking" was almost identical for the two groups ($r = .75$).

*Opinions.* One section of the questionnaire asked the subjects to indicate,

on a five-point scale ranging from "strongly agree" to "strongly disagree," their opinions on 24 statements relative to social, economic, and political issues, and also on two statements regarding the role of physical education and athletics in education. Significant group differences were discovered in the responses to six of the 26 items.

In general, these differences indicated that the experimental group was more conservative than was the control group. For example, a significantly greater proportion of the experimental group agreed that it was better to buy from private companies than from cooperatives, that the Communist party should be made illegal in the United States, and that a retail sales tax was a good way for a state to balance its budget. Also, the experimental group expressed more favorable opinions relative to physical education and athletics in education.

To more rigorously check group differences in this area, 12 items were selected by a jury as being most likely to differentiate between the groups as to their position on the radical-reactionary continuum. The responses on these 12 were then quantified by a scaling procedure, the scale scores determined for each group, and these scores compared by use of the *t* test of significance. This procedure again showed that the experimental group was significantly more conservative than was the control group.

Neither group was more opinionated than the other, as indicated by the tendency to check one of the extreme categories—"strongly agree" or "strongly disagree."

*Civic activities.* The respondents as a whole participated more in the casual, less active types of civic affairs than in the more active ones. No significant group differences were discovered in over-all participation, nor with respect to 12 of the 14 activities listed in the questionnaire. A significantly greater proportion of the control group indicated that they had voted in an election during the past two years, and read regularly a magazine dealing with current political and social issues.

*Military Service.* Half of the respondents served in the armed forces during the last war. Among the important characteristics differentiating the two groups in this area were the following:

1. A significantly larger proportion of the experimental group was in the service.
2. The experimental group had a larger proportion who served in the Navy, while more of the control group were in the Army.
3. A significantly larger proportion of the experimental group entered the service as officers.
4. The control group spent, on the average, a significantly longer time in the service.
5. The two groups indicated similar degrees of relationship of military duties to civilian duties, and similar opinions about military service (surprisingly high in both cases).

*Marital status.* Nine out of every ten of the respondents were married. The groups did not differ significantly in this respect. However, the average number of children was significantly greater for the experimental group than for the control group.

## Conclusions

It has been shown that the two basic groups in this study, distinguished initially on the basis of athletic talent, could also be distinguished on the basis of certain other characteristics. However, it is not being suggested that the possession of athletic talent was the sole, or even the primary, cause of these differential characteristics. Nevertheless, the very fact that those who possessed athletic talent of a high order also possessed certain other characteristics has considerable significance in itself. For one, it gives a more complete picture of what the athletically talented are like. It further serves to throw suspicion on certain popular conceptions about college athletes; for example, that they "never amount to much" in adult life, or that they fail to carry over into adult life any continued interest in athletics.

Considered in relation to similarities discovered between the groups, it in some instances raises the possibility of causation. For example, the significantly higher income of the "M" men could probably not have been due to differences between the groups in scholarship, college from which graduated, number of advanced degrees obtained, or vocational mobility, because there were no significant group differences with respect to these characteristics.

In general, it can be concluded that the "M" men could be differentiated in their post-collegiate status principally by the following characteristics:

1. They continued to show an interest in activities of an athletic nature.
2. Vocationally, they were distinguished principally by markedly higher incomes.
3. They tended to be more conservative.
4. Both the nature and the extent of their military service differentiated the "M" men from the control group. Specifically, more were in the service, more entered as officers, and they tended to serve in the Navy rather than in the Army.

## Summary

This study was designed to be an objective investigation of certain aspects of athletic talent. It was not undertaken in an attempt to either attack or defend college athletics. Nevertheless, the findings which have been presented are such that some general comments relevant to this point seem appropriate.

The entire program of college athletics has periodically been subjected to considerable criticism. Some of this has been by the unthinking or the misinformed; however, much of it has arisen from a sincere concern about the role of athletics in collegiate life. The issues are numerous and complex, and most of them are not closely related to this investigation. However, to the extent that the findings of this study might bear on this question, they certainly have indicated little which would reflect unfavorably on the role of collegiate athletics, and much which would reflect favorably.

# The Relationship of Extreme Somatotypes to Performance in Motor and Strength Tests

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IT WAS THE purpose of this study to further clarify the relationship of endomorphy, mesomorphy, and ectomorphy to the performance of motor skills and tests of strength. The authors believed that the use of extreme body types would be a useful approach since this procedure would tend to hold constant (rule out) two body components while a third was being investigated.

The method of body typing used in this study has been clearly explained by Sheldon, Stevens, and Tucker (6). A modification of their descriptive criteria follows:

ENDOMORPHY: Characterized by roundness and softness of body; central concentration of mass; no muscle relief; and short, tapering limbs.
MESOMORPHY: Characterized by squareness and hardness of body; large bones; heavy musculature; broad shoulders with pyramiding trapezius; and broad hips with sturdy pelvis.
ECTOMORPHY: Characterized by linearity and delicacy of body; shoulders narrow and lacking in muscular relief; fingers and toes generally slender and long; and head may appear too large for slender neck.

Cureton (1) has suggested that an empirical rating scale be used in associating somatotypes with fitness test results. Sills (2) found that ectomorphy was a reciprocal of both endomorphy and mesomorphy, and identified the latter two as factors in a factorial study. He also found that strength tests and skill tests were related to the factor mesomorphy, but were, with the exception of low loadings for the strength tests, unrelated to the factor endomorphy. Sills indicated that a better analysis would have resulted if his subjects had been more heterogeneous.

Willgoose (3) found a number of significant relationships between various body types and performance on the PFI score. The highest mean score was made by the mesomorph-ectomorph group (three subjects) while the extreme mesomorphs (32 subjects) recorded the next highest mean score. He concluded that endomorphy was a limiting factor in physical fitness and that mesomorphy is associated with physical fitness (as measured by the PFI). Carpenter (7) in a factorial study identified "dead weight" as a factor in respect to physical activity. Brady (8) in a later study concerning the effect of excess weight upon motor skills defined "dead weight" as that part of the body weight which was a handicap in physical activity.

## Procedure

Forty-three University of Iowa students served as the subjects for the present study. These students were divided into three groups of 14 mesomorphs,

13 endomorphs and 16 ectomorphs. Each was selected as a member of one of these groups on the basis of a high rating (5 to 7) for one component and a low rating (below 3) for the other two components. It was hoped that more extreme body types could have been tested, but these students composed the best sample that could be obtained from the male population of the University of Iowa.

Each subject was required to take 12 tests. The experiment was designed to include three tests of each of the following elements basic to physical activity (1) strength, (2) agility, (3) speed, and (4) endurance. Dynamometric tests of combined hand grip strength, back and leg strength, and back strength were given the subjects.

The tests used to measure agility included the squat thrust (Burpee), the side-stepping test, and the crisscross test. These tests were administered as recommended by McCloy (4). The squat-thrust test was extended to 20 seconds to increase the range of scores.

For endurance, a modification of Carlson's Test (5) was employed. The subjects alternately ran in place for ten seconds and rested ten seconds until they had completed a total of five bouts of running. Electric contacts were fitted to the portable platform which supported the subject, and the score for his left foot was recorded by an electric counter.[1] A fatigue index was computed by dividing the total number of steps for the first four bouts by the number of steps for the fifth bout. The 200-yard run and the mile run were also used to test endurance.

The 50-yard dash, running in place for ten seconds, and punching speed for ten seconds comprised the three tests of speed of movement. For the punching test, the same platform which had been used for the running in place test was set upon a table in a vertical position. The subject faced the platform and punched as rapidly as possible for ten seconds. He was instructed to alternate left and right blows. The action of the arms was restricted to a backward and forward type of movement with the elbows held close to the sides of the trunk. The subject wore boxing gloves, and the number of blows for one hand was recorded on the electric counter.

Significance ratios (Tables 1, 2, and 3) were determined between the extreme body types for each of the tests except the mile run. The mile run was not included in Table 1 or Table 3 since none of the endomorphs were able to complete the test.

**Analysis of Data**

*Mesomorphs and Endomorphs.* For eight of the tests the obtained differences were statistically significant[2] in favor of the mesomorphs. For the back lift,

[1] In an unpublished study by William McCabe, a graduate student at the State University of Iowa, reliability coefficients of correlation for the step counter tests and punching test were above .90.

[2] E. F. Lindquist. *A First Course in Statistics.* Boston: Houghton Mifflin Company, 1942, pp. 138, 240. The null hypothesis was rejected at the five-percent and higher levels of significance.

TABLE 1

*Significance of Obtained Differences for Mesomorphs and Endomorphs*

| Test | Mean (Meso.) | Mean (Endo.) | $t$ | Level of Significance |
|---|---|---|---|---|
| 1. Combined hand grips (lb.) | 261.10 | 228.80 | 2.34 | 5.0 |
| 2. Let lift (lb.) | 1406.70 | 918.50 | 4.33 | 0.1 |
| 3. Back lift (lb.) | 475.30 | 406.90 | 1.86 | 10.0 |
| 4. Squat thrust (20″) | 11.50 | 9.80 | 4.28 | 0.1 |
| 5. Crisscross test | 33.80 | 21.60 | 7.01 | 0.1 |
| 6. Side-step test | 13.26 | 10.81 | 4.02 | 0.1 |
| 7. 50-yard dash | 6.50* | 7.70 | 7.74 | 0.1 |
| 8. Punching speed (10″) | 82.90 | 74.90 | 1.72 | 10.0 |
| 9. Ten second spot run | 50.50 | 40.30 | 4.96 | 0.1 |
| 10. Fatigue index | 4.34* | 4.38 | 1.85 | 10.0 |
| 11. 200-yard run | 27.60* | 34.40 | 12.64 | 0.1 |
| 12. Mile | 6.16* | | | |

* Time events: Lowest mean indicates best group performance.

TABLE 2

*Significance of Obtained Differences for Mesomorphs and Ectomorphs*

| Test | Mean (Meso.) | Mean (Ecto.) | $t$ | Level of Significance |
|---|---|---|---|---|
| 1. Combined hand grips (lb.) | 261.10 | 212.80 | 4.37 | 0.1 |
| 2. Leg lift (lb.) | 1406.70 | 790.00 | 6.49 | 0.1 |
| 3. Back lift (lb.) | 475.30 | 381.20 | 2.89 | 1.0 |
| 4. Squat thrust (20″) | 11.50 | 11.20 | 1.50 | 20.0 |
| 5. Crisscross test | 33.80 | 26.60 | 3.44 | 1.0 |
| 6. Side-step test | 13.26 | 12.06 | 2.10 | 5.0 |
| 7. 50-yard dash | 6.50* | 7.00 | 4.97 | 0.1 |
| 8. Punching speed (10″) | 82.90 | 77.10 | 1.26 | 30.0 |
| 9. Ten second spot run | 50.50 | 46.60 | 1.75 | 10.0 |
| 10. Fatigue index | 4.34 | 4.31* | .29 | 80.0 |
| 11. 200-yard run | 27.60* | 29.90 | 4.77 | 0.1 |
| 12. Mile | 6.16* | 6.44 | | |

* Time events: Lowest mean indicates best group performance.

TABLE 3

*Significance of Obtained Differences for Ectomorphs and Endomorphs*

| Test | Mean (Ecto.) | Mean (Endo.) | $t$ | Level of Significance |
|---|---|---|---|---|
| 1. Combined hand grips (lb.) | 212.80 | 228.80 | 1.57 | 15.0 |
| 2. Leg lift (lb.) | 790.00 | 918.50 | 1.74 | 10.0 |
| 3. Back lift (lb.) | 381.20 | 406.90 | 1.20 | 30.0 |
| 4. Squat thrust (20″) | 11.20 | 9.80 | 3.29 | 1.0 |
| 5. Crisscross test | 26.60 | 21.60 | 2.21 | 5.0 |
| 6. Side-step test | 12.06 | 10.81 | 2.26 | 5.0 |
| 7. 50-yeard dash | 7.00* | 7.70 | 4.72 | 0.1 |
| 8. Punching speed (10″) | 77.10 | 74.90 | .42 | 70.0 |
| 9. Ten second spot run | 46.60 | 40.30 | 3.17 | 1.0 |
| 10. Fatigue index | 4.31* | 4.38 | .83 | 50.0 |
| 11. 200-yard run | 29.90* | 34.40 | 5.59 | 0.1 |
| 12. Mile | 6.44* | | | |

* Time events: Lowest mean indicates best group performance.

punching speed, and fatigue index tests a 10-percent level of significance was obtained, and although these results were not statistically significant, they may be of value to those who do future research in this area. The selection of more extreme body types than was possible in the present study, for an example, would probably result in the rejection of the null hypothesis for the three tests for which a 10-percent level of significance was obtained.

A 30- or 40-percent level of significance, however, would discourage the future use of a test for the purpose of discriminating between extreme body types. For these reasons, the authors have indicated the level of significance for each test at which the null hypothesis was accepted or rejected.

*Mesomorphs and Ectomorphs.* Significant differences in favor of the mesomorphs were obtained for the three strength tests, two of the agility tests, one speed test, and one endurance test. The mean scores of the mesomorphs were better for all of the tests with the exception of the fatigue index.

Since two of the agility tests discriminated between the two body types while the third did not, it appeared that the same element (agility) was not being tested by all three tests. Similar results were found for the speed and endurance tests. These results are considered in more detail under the heading of Discussion.

*Endomorphs and Ectomorphs.* The mean scores for the endomorphs on the strength tests were higher than those of the ectomorphs, although not large enough to be statistically significant. For all of the other tests, with the exception of the punching speed test and the fatigue index test, the differences were statistically significant in favor of the ectomorphs.

**Discussion**

The authors recognized that the structural differences in the body types influenced the results, and the following relationships were believed to be significant.

The strength tests were valid tests for the three extreme types. The authors found no reason to believe that any one type had a structural advantage relative to the mechanics involved in the tests. The dominance of the mesomorphs over the endomorphs and the ectomorphs was attributed to their muscular development and, although significant differences were not found between the endomorphs and the ectomorphs, it was interesting to observe that the obtained differences were all in favor of the endomorphs. This observation tends to substantiate the point of view that a subject with a high rating in endomorphy must have sufficient strength to move his massive body. If the strength tests used for this study had been the pull-up or push-up type of test, the endomorphs would, of course, have done very poorly.

The mesomorphs and the ectomorphs were superior to the endomorphs in the three agility tests. These results were attributed to the "dead weight factor" (7, 8) which was a serious handicap to the endomorphs. For two of the tests, crisscross and side-step, which involved translatory movement[3] of the

[3] The term translatory movement is used to indicate the movement which involves the transfer of the body mass from one place to another place.

body the mesomorphs were superior to the ectomorphs, but in the other test (squat thrust for twenty seconds) which was performed on a "spot," a significant difference was not obtained. The authors believed that the mesomorphs had a proportionately greater amount of strength relative to their body mass than did the ectomorphs and, therefore, did better on the two agility tests requiring translatory movement.

Of the three speed tests which were employed, the 50-yard dash was the only one which involved the movement of the body over a given distance. On this test the mesomorphs were superior to both of the other groups, and the ectomorphs were superior to the endomorphs. This result was interpreted in the same manner as those obtained for the crisscross and side-step tests—the endomorphs were handicapped most by excess weight and the ectomorphs next by insufficient strength. The punching speed test was not discriminatory, although the highest mean score was recorded for the mesomorphs, next highest for the ectomorphs, and lowest for the endomorphs. The results for the ten-second spot run indicated that the mesomorphs and ectomorphs were superior to the endomorphs, and although the mesomorphs took almost four more steps (for one foot) in ten seconds than the ectomorphs, a significant difference was not obtained.

The most significant result for the endurance tests was that obtained for the mile run, since not one of the endomorphs was able to run this distance. The mesomorphs performed better than the ectomorphs but the difference was not significant. The 200-yard run substantiated the results of the other tests which involved rapid movement for a comparatively short period of time. Both the mesomorphs and ectomorphs were superior to the endomorphs, and the mesomorphs were superior to the ectomorphs. The third test for measuring fatigue was developed by the authors and was named the fatigue index test.

It was the belief of the authors that the subjects would experience varying degrees of fatigue with five ten-second bouts of spot running, and that the first four bouts divided by the fifth bout would produce a useful index. The test did not, however, serve to differentiate between the three extreme body types. The failure of the test to differentiate was caused either by the subjects "pacing" themselves during the course of the five bouts, or the test was not of sufficient duration. This type of test should be very useful in determining endurance if the subjects are co-operative in going "all out" from start to finish.

**Summary and Conclusions**

Fourteen mesomorphs, 13 endomorphs, and 16 ectomorphs were selected for this study. Twelve physical tests were administered to all subjects and *t* ratios were computed to determine the statistical significance of the obtained differences between the three groups. These differences did not indicate that any one of the three body types was superior to the other two body types in strength, agility, speed, or endurance; however, on the basis of the statistically significant results that were obtained, the authors reached the following conclusions:

1. Mesomorphs are stronger than endomorphs and ectomorphs.
2. Endomorphs are stronger than ectomorphs (although statistically sig-

nificant differences were not obtained, the mean scores were in favor of the endomorphs).

3. Ectomorphs are superior to endomorphs in speed, agility, and endurance.

4. Mesomorphs are superior to both endomorphs and ectomorphs in agility, speed, and endurance.

5. Excess weight is a handicap to endomorphs and insufficient strength is a handicap to ectomorphs in the performance of physical tests.

6. Consideration should be given body types in formulating standards for achievement on strength tests and motor tests.

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# A Survey of 504 Families to Determine the Relationships Between Certain Factors and the Nature of the Family Recreation Program

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THE NEW FAMILY leisure, which has been made possible by the invention of the machine and its almost continuous development towards the substitution of machine power for manpower, has created vital problems not alone for industry and education but for the family as well.

Families are headed for more and more leisure (5). During the past 100 years the work week has shrunk from seven to five days, the work day from 14 hours to eight and even less in many instances (1). All indications now point to even shorter work periods in the imminent future.

However, the very changes which have given us more leisure have also tended to destroy the very base of our traditional leisure activities. Spontaneous and informal family life and recreation have largely disappeared. In its place commercial recreation has "reared its ugly head."

One of the strongest characteristics of early pioneer history in this country was the strength of the family ties. The reasons for this strength were undoubtedly partly economic and partly social. Families were generally without adequate funds for all but the barest essentials for living, had little or no equipment and hence there was a tendency in everyday living to work together and to play together as a unit.

The present drive for recreation, both in its ways and means of satisfying leisure requirements, stands in striking contrast to earlier attitudes towards leisure and its use.

Radical changes have taken place in this use of leisure from the time of our colonial period with its emphasis on self-preservation, down through the successive periods which were more or less controlled or directed by the churches, private clubs, organizations, welfare agencies, commercial groups, governmental agencies, radio, and now possibly television.

Despite the fact that education has accepted "the worthy use of leisure time" as one of its goals, little has been done to achieve this form of education. The efforts to determine what education should accomplish in the light of the needs of the modern family constitutes a most significant responsibility of educators, social workers, and clergy. As conditions and demands of family life change, so too should the education of the family. Conspicuous among the changes so apparent today is the matter of the use of leisure. Education must accept this challenge or fail in its fundamental responsibility to mankind.

**Purpose of the Study**

The intent of this study is to ascertain the *status quo* of family recreational programs, to determine the factor or factors which most seriously affect the family's participation in these programs and to discover which activities serve as unifying, strengthening forces in the development of family life.

**Need for the Study**

There have been many indications of the need for research in this particular area. One or two of them will suffice for the purposes of this digest.

Dr. Tribble (8), President of the Andover-Newton Theological Seminary, recently stated:

"We are in great danger of destroying the human family because we have not developed moral character. The world is in tragic confusion. We are not able to agree on peace treaties. We can not solve industrial problems. Intemperance, drunkenness, gambling and immorality are increasing. Divorces and separations are multiplying. Fear is the dominant motive of our day. Business and labor are afraid of each other. Governments are afraid of the people."

Herbert Hoover (3), former President of the United States, said:

"This civilization is not going to depend upon what we do when we work, so much as what we do in our time off."

Conferees at the White House Conference on child health and protection felt much the same when they stated (11):

"Family recreations are not well provided for, in either country or city, and there is particular neglect of recreation within the home. At present only the exceptional family makes adequate provisions for home recreation."

The question of a solution for many of these ills fall with propriety within the sphere of the development of individual, family and national morale, as well as in the achievement of a philosophy of living. These are inextricably interwoven, especially in childhood but also in later years, with the good use of leisure time.

**Definition of Terms**

*Recreation*—the term is intended to include all voluntary leisure time participation in activities or skills.

*Activity*—the term is defined as a skill or interest in which one can participate either actively or as a spectator.

*Leisure*—is that time which is available for pursuits freely decided upon with no ulterior compulsions.

*Family Use*—occurs when two or more members of the family, at least one of whom must be a parent or adult, participate together in the activity at the same time.

*Home Use*—occurs when the participation in the activity takes place at the residence of the family group. Home is intended to include all the areas immediately adjacent to the house and also any special seasonal residence.

**Procedures**

To obtain the answer to the questions pertinent to this study, a questionnaire was devised. This inquiry form called for three general types of information: personal family data, family participation in recreational activities, and the family's attitude toward its recreation program This questionnaire was

mailed to 864 families and 504 were returned in time to be included in the study. Additional ones were received from 58 families after tabulation had been started and an adequate sample had been achieved. These figures show, on a percentage basis, that 65 percent of the questionnaires distributed were returned. The *t* ratio (6) for this percentage is 6.36. The returns came from 38 states, territories, and countries.

**Sample in the Study**

A review of the literature of the field indicated that financial income was one of the most important factors in determining the recreational practices of individuals (4). It was obvious that if income was an important factor for an individual it would be proportionally even more important with the family as a whole. The returns were compared with the *Consumer Income Reports for Non-Farm Husband and Wife Families* (9) to prove the adequacy of the sample. Table 1 gives this comparison. Despite the fact that family income

TABLE 1

*A Comparison of the Income Levels for Non-Farm Husband and Wife Families[1] with the 504 Families in the Sample*

| Income[2] | % of Non-Farm Pop. Receiving Income[3] | Age Level of Wage Group Receiving Income | % of Sample Receiving Income | Average Age of Sample | No. Cases in Sample | Critical Ratio |
|---|---|---|---|---|---|---|
| Under $3,000 | 31.6 | 45–54 | 30.7 | 44.6 | 152 | .246 |
| $3,000 to $4,000 | 23.9 | 35–44 | 22.8 | 41.0 | 115 | .300 |
| $4,000 to $5,000 | 13.5 | 45–54 | 14.8 | 45.5 | 75 | .265 |
| $5,000 to $6,000 | 10.5 | 35–45 | 10.1 | 38.0 | 51 | .090 |
| $6,000 to $7,000 | | | 3.9 | 43.6 | 20 | |
| $7,000 to $8,000 | 8.5 | 35–45 | 3.7 | 43.4 | 19 | .780 |
| $8,000 to $10,000 | | | 4.2 | 45.4 | 21 | |
| | | | 11.8 | | | |
| Over $10,000 | 3.8 | 44–54 | 10.1 | 46.2 | 51 | 1.40 |

[1] U. S. Department of Commerce, Bureau of Census, *Current Population Reports; Consumer Income*. Series P-60, No. 3, Washington, D. C., June 1948.

[2] The Consumer Income (Bureau of Census figures) was grouped from $6,000 to $10,000. Therefore, the sample income was grouped or combined in the same manner for comparison by critical ratio.

[3] The total of the percentages in this column is not 100 since the percentages are from different groups of figures based on different age groups.

was determined to be the most fundamental and basic means of establishing the sample for this study, it was thought wise to compare the sample with still another approved criterion. This second criterion was a comparison of the sample with *The Bureau of Census Figures, for the Classification of Employment*. This comparison will be found in Table 2.

The sample contained 504 families with a total membership of 2,184. The range in the number of children in these families was from zero to nine. The mean family size was 4.3 members. This compares favorably with the mean size of all families in the United States.

TABLE 2

*A Comparison of the Bureau of Census Figures for Classification of Employment with the Sample Distribution of Employment*

| Forms of Occupation | Percentage in Federal Classification | Sample | | Critical Ratio |
|---|---|---|---|---|
| | | No. | % | |
| Agriculture | 17.1 | 10 | 2.2 | −3.37* |
| Mining | 2.5 | 4 | .008 | −1.23 |
| Electric Light gas Power | 0.7 | 13 | 2.8 | .45 |
| Manufacturing | 22.6 | 16 | 11.9 | −2.43 |
| Construction | 3.4 | 48 | 10.4 | 1.40 |
| Transportation | 7.0 | 27 | 5.8 | .245 |
| Communication | 1.1 | 16 | 3.6 | .637 |
| Trade | 16.2 | 95 | 20.6 | 1.04 |
| Finance | 3.2 | 30 | 6.6 | .666 |
| Government | 6.8 | 23 | 4.9 | −.430 |
| Service | 12.6 | 109 | 23.7 | 2.70* |
| Miscellaneous | 6.8 | 31 | 6.7 | −.021 |
| Total | 100.0 | 461 | 100.0 | |

NOTE: Critical ratios marked with an asterisk are considered to be significant.

## Validation of the Questionnaire

Two methods were used to determine the validity of the questionnaire. The first, and probably most basic technique, is commonly known as "face validity" and has the support of Rulon. Since the questions listed in the questionnaire were all valid questions of practices in family recreation, personal family data, and the family's attitude toward its recreation program, the questionnaire was a valid instrument from the standpoint of face validity. Rulon (7) states: "The obviously valid test is its own criteria." "... Thus we see that the direct observation of the things and processes which are the aims of instruction is the final proof of validity as compared with the correlation coefficient of validity which is at best secondary."

The second method was the selection of 50 randomly selected questionnaires, with more or less local addresses, for a recheck. Without prior information the author called on these 50 families for a discussion of their returns. The discussions took the form of "What evidence is there that the family actually participated as described in the questionnaire?" Some irrefutable evidence had to be shown that the participation recorded had occurred. This evidence

took many forms, typically: "What kind of fishing tackle do you use? Where is the best place nearby for a picnic, swimming, etc.? Do you ever save ticket stubs? Who is your favorite motion picture actress or actor? Which book have you enjoyed reading recently?" The resultant validity coefficient between the "validity check" and the questionnaire was .883, with a probable error of plus or minus .063.

Though validity is usually conceived as encompassing reliability it was planned to determine the reliability of the instrument by means of a test and retest.

The questionnaire was given to 36 college women in a classroom situation on a Monday morning with the request that they answer it describing what their family group did for recreation. That same morning the girls mailed to their parents a second questionnaire with the request that the remainder of the family answer it. The two questionnaires were matched and a reliability coefficient of .86, with a probable error of plus or minus .09, was secured.

The level of significance utilized in this study is the 1-per-cent level or 2.576 times the standard error.

**Analysis of the Data**

Each family because of its unique origin, background of culture, experience and understanding has formulated its own program of activities for the use of its leisure. With this point of view in mind, we can see from Tables 3 and 4 just what family units are doing for recreation.

Tables 3 and 4 indicate two things. The first fact indicated is that families are participating in activities within these classifications for some significant reason. Secondly, that there are only three activities in use by 75 per cent (S.E.% 2.00) or more of the families. This indicates that the great majority of the families have few interests in common with other families and that the major participation occurs in a rather wide range of activities.

TABLE 3

*The Rank of the Activity Classifications according to the Frequency of Participation, Together with the Percentage of Total Participation and the Number and Percentage of Families using at Least One Activity in the Classification*

| Rank of Classification According to Participation | No. of Participants in the Classification | % of all Participating | No. of Families Participating Classification | % of Families Participating |
|---|---|---|---|---|
| Nature-Outing Activities | 2767 | 21.0 | 471 | 93 |
| Spectator Activities | 2139 | 16.3 | 475 | 94 |
| Social Activities | 2059 | 15.7 | 449 | 89 |
| Sports Participation | 1597 | 12.2 | 404 | 80 |
| Spectator Sports | 1504 | 11.4 | 375 | 74 |
| Participation in Music, Mental, Drama, etc. | 1398 | 10.6 | 436 | 87 |
| Organizational Interests | 748 | 5.6 | 283 | 56 |
| Arts and Crafts | 750 | 5.6 | 301 | 59 |
| Collection of Items | 211 | 1.6 | 113 | 22 |
| Total | 13,173 | 100.0 | 504* | 100* |

NOTE: Starred items (*) are not totals of the columns.

TABLE 4

*The Activities that Were Reported to be in Use by 100 or More of the Families Studied*

| Activity | No. of Families Reporting | % of Families Reporting |
|---|---|---|
| 1. Auto riding | 440 | 87 |
| 2. Picknicking | 411 | 82 |
| 3. Motion pictures | 385 | 76 |
| 4. Reading | 359 | 71 |
| 5. Card games | 343 | 68 |
| 6. Swimming | 308 | 61 |
| 7. Watching baseball | 298 | 59 |
| 8. Radio dramas | 296 | 59 |
| 9. Radio concerts | 288 | 57 |
| 10. Gardening | 275 | 55 |
| 11. Social dancing | 245 | 49 |
| 12. Beach parties | 230 | 46 |
| 13. Excursions | 224 | 44 |
| 14. Checkers | 193 | 38 |
| 15. Fishing | 186 | 37 |
| 16. Musical comedies (stage) | 186 | 37 |
| 17. Drama (stage) | 179 | 36 |
| 18. Barbecues | 179 | 36 |
| 19. Watching basketball | 174 | 35 |
| 20. Informal singing | 169 | 34 |
| 21. Bowling | 168 | 33 |
| 22. Puzzles | 166 | 33 |
| 23. Ice skating | 163 | 32 |
| 24. Christmas carolling | 163 | 32 |
| 25. Symphony concerts | 159 | 31 |
| 26. Watching football | 156 | 31 |
| 27. Croquet | 149 | 30 |
| 28. Cookery | 146 | 29 |
| 29. Amateur theatricals | 144 | 28 |
| 30. Entertainments | 141 | 28 |
| 31. Basket suppers | 140 | 27 |
| 32. Paper-pencil games | 139 | 27 |
| 33. Hiking | 135 | 27 |
| 34. Coasting | 133 | 26 |
| 35. Table tennis | 125 | 25 |
| 36. Watching ice hockey | 125 | 25 |
| 37. Rowing | 124 | 25 |
| 38. Night clubs | 118 | 23 |
| 39. Camping | 117 | 23 |
| 40. Knitting | 115 | 23 |
| 41. Bicycle riding | 115 | 23 |
| 42. Mental games | 113 | 22 |
| 43. Photography | 113 | 22 |
| 44. Winter sports | 111 | 22 |
| 45. Book club | 104 | 20 |
| 46. Softball | 103 | 20 |
| 47. Parchesi | 102 | 20 |

Table 5 indicates that there is a very great discrepancy in the number of different recreational activities engaged in by the families studied.

TABLE 5

*The Number of Different Recreational Activities Engaged in by the 504 Families Studied*

| No. of Different Family Recreation Activities | No. of Families Reporting | Per Cent of Families |
|---|---|---|
| 0–4 | 26 | 5.25 |
| 5–9 | 40 | 7.9% |
| 10–14 | 59 | 11.7% |
| 15–19 | 78 | 15.5% |
| 20–24 | 70 | 13.9% |
| 25–29 | 75 | 14.9% |
| 30–34 | 34 | 6.7% |
| 35–39 | 39 | 7.7% |
| 40–44 | 20 | 3.9% |
| 45–49 | 24 | 4.8% |
| 50–54 | 14 | 2.7% |
| 55–59 | 10 | 1.9% |
| 60–64 | 10 | 1.9% |
| 65–69 | 2 | .5% |
| 70–74 | 3 | .7% |
| Total | 504 | 100.0% |

NOTE:
Median: 21.0 S.D.: 14.85
Mean: 24.8 S.E. Mean: 2.90

In studies of the recreational practices of individuals, considerable importance has been attached to where the participation occurred. This is also important in a consideration of family recreation. Quite obviously some activities can be best engaged in away from the home while others lend themselves almost entirely to a home situation. Table 6 lists the activity classification and the extent of their use according to location.

TABLE 6

*The Location of the Participation in all the Recreation Activities, Listed According to Their General Classification, Reported as in Use in the Family Recreation Program*

| Classification | At or adjacent to the Home | | Away from the Home | | S.E. % | Total No. Participations |
|---|---|---|---|---|---|---|
| | No. Participating | % of Participation | No. Participating | % of Participation | | |
| Nature and Outing Activities | 1183 | 44 | 1584 | 56 | 1.00 | 2,767 |
| Spectator Activities | 627 | 29 | 1512 | 71 | 1.10 | 2,139 |
| Social Activities | 1298 | 63 | 761 | 37 | 1.20 | 2,059 |
| Sports Participation | 771 | 48 | 826 | 52 | 1.30 | 1,597 |
| Spectator Sports | 425 | 28 | 1097 | 72 | 1.30 | 1,504 |
| Participation in Music, Mental, etc. | 1231 | 88 | 167 | 12 | 1.00 | 1,398 |
| Organizational Interests | 45 | 6 | 739 | 94 | .90 | 784 |
| Arts and Crafts | 633 | 84 | 117 | 16 | 1.40 | 750 |
| Collection of Items | 203 | 96 | 8 | 4 | 1.40 | 211 |
| Total | 6416 | 49% | 6,793 | 51% | .498 | 13,209 |

THE FACTORS THAT AFFECT FAMILY PARTICIPATION IN RECREATIONAL PROGRAMS

*Income.* There have been frequent mentions made in the various studies dealing with programs of recreation for individuals of the importance of the income level and its relationship to what people do for recreation (4).

It is self-evident that every form of commercial recreation, because of its inherent nature, requires and demands financial returns for its continued existence. This holds true, also, in a great many other types of recreational programs including those of churches, fraternal organizations, social, and other semi-public agencies, and even extends into the recreation programs of the governmental agencies where the newly accepted concept is to have adult programs pay their own way.

Unless the family income provides a financial margin over and above the needs for normal, basic living, there can be little or no participation in the popular and socially necessary forms of recreation without sacrificing, in some basic part, another fundamental need.

The question that arises then is whether or not income level has any significant effect on the number of activities engaged in by the family as a group. This question is clearly answered by the data presented in Table 7, which indicate that there is no significant difference in the ranges according to income level. There is, however, an indication that the income levels between $5,000 and $7,000 have the highest mean numbers of activities. Possibly this indicates that those not pressed by low income level nor forced by type of employment and the time necessarily devoted to earn a large income have both time and money enough to engage more often in family recreation activities.

TABLE 7

*The Mean Scores Listed According to the Family Income for the Number of Recreations Used in the Family Recreation Programs*

| Income Level | *Mean Scores* Number of Activities Participated in by the Families | Range of Scores | No. of Cases | S.D. | S.E. Mean |
|---|---|---|---|---|---|
| Under $3,000 | 19.74 | 0–64 | 152 | 13.50 | 1.09 |
| $3,000 to $4,000 | 26.45 | 0–74 | 115 | 15.35 | 1.43 |
| $4,000 to $5,000 | 27.00 | 0–71 | 75 | 14.50 | 1.68 |
| $5,000 to $6,000 | 32.10 | 2–74 | 51 | 13.90 | 1.96 |
| $6,000 to $7,000 | 32.27 | 15–69 | 20 | 15.25 | 3.51 |
| $7,000 to $8,000 | 29.05 | 1–58 | 19 | 14.45 | 3.40 |
| $8,000 to $10,000 | 26.50 | 5–58 | 21 | 15.10 | 3.37 |
| Over $10,000 | 25.80 | 0–63 | 51 | 11.65 | 1.64 |

Since recreation is largely a matter of attitude (2), the part income has on the establishment of the families' attitudes toward recreation is of considerable importance. If the family program is constantly affected by such statements as: "I'm sorry, children, but that costs too much," and "We can't afford to do that," there is bound to be established a concept that the most enjoyable

activities are obtainable only through purchase at financial cost. This in turn can result in the development of the attitude that low or non-cost activities are not as enjoyable as others and therefore are only to be used as a last resort or as "fill-ins."

Table 8 gives an indication of the families' attitude toward recreation and the income level.

The data presented in Table 8 indicate that the per cent of families that are satisfied with their program of recreation increases in accordance with the rise in income up to the $6,000 level. Families with income of $5,000 to $7,000 appear to be most satisfied with their recreation programs. Also indicated is the fact that a significant number of the total families feel their program is unsatisfactory.

TABLE 8

*The Number and Percentages of Families Listed According to their Family Income, Reporting their Reaction to the Family Recreation Program*

| Income Level | Number of Families Reporting | Program Considered Satisfactory | | Program Considered Unsatisfactory | | S.E. of the % | Test Significance *t* Ratio |
|---|---|---|---|---|---|---|---|
| | | No. Cases | % | No. Cases | % | | |
| Under $3,000 | 143 | 54 | 37.7 | 89 | 62.3 | 4.10 | *2.75 |
| $3,000–$4,000 | 108 | 39 | 37.8 | 69 | 62.2 | 4.70 | *2.40 |
| $4,000–$5,000 | 62 | 30 | 48.3 | 32 | 51.7 | 6.4 | .13 |
| $5,000–$6,000 | 47 | 25 | 53.1 | 22 | 46.9 | 7.30 | .56 |
| $6,000–$7,000 | 19 | 9 | 50.0 | 9 | 50.0 | 1.60 | — |
| $7,000–$8,000 | 16 | 7 | 43.7 | 9 | 56.3 | 1.71 | .13 |
| $8,000–$10,000 | 51 | 18 | 32.5 | 33 | 64.8 | .67 | 1.97 |
| Total | 466 | 194 | 41.6 | 272 | 58.4 | .024 | 3.21 |

*Restrictions to Good Family Recreation.* Family preferences in the use of leisure vary widely. It is reasonable to assume that because of the very breadth and nature of the activities available for recreation no two families have exactly the same type of family program. This variation in program is the result of many factors or combinations of factors. These range from interest, environment, tradition and experience to some very specific and concrete ones such as the lack of sufficient time to participate. The purpose of this aspect of the study is to uncover some of the more common and tangible factors that affect the families' recreation as well as to determine the effect they have on the families' programs.

Table 9 indicates that a significant percentage of the families felt that their recreation program had been restricted by one or more factors.

Table 10 indicates that not one of the listed factors was determined to be statistically significant as a cause in the restriction of family recreation programs. Actually there is an inverse ratio between non-restricted families and the restrictions listed above. This is indicated by the fact that there is not a

TABLE 9

*The Numbers and Percentages of the Families in the Study that Felt their Recreational Program Had Been Restricted by One or More Factors*

| Classification | Number of Families Reporting | Percentage of Families Reporting | Standard Error of Percentage | *t* Ratio |
|---|---|---|---|---|
| Restricted | 377 | 74.8 | 2.3 | 10.65 |
| Unrestricted | 127 | 25.2 | | |
| Totals | 504 | 100.0 | | |

single positive *t*-ratio. The negative *t*-ratios indicate that these so called "restricting factors" were not considered, by a statistically significant percentage of the families reporting, to be important enough in themselves to make a family feel that their recreational program was actually restricted. The criterion used was a parameter value of 51 per cent.

TABLE 10

*The Significance, Frequency and Percentage of Mention of Each Listed Restriction to Family Recreation Programs*

| Type of Restriction | Restricted Families | | Non-Restricted Families | | Total No. Restrict. | S.E. % | *t* Ratio* |
|---|---|---|---|---|---|---|---|
| | No. Restr. | % | No. Restr. | % | | | |
| Insufficient income | 151 | 31 | 349 | 69 | 500 | 2.2 | −9.09 |
| Insufficient time to participate | 214 | 46 | 249 | 54 | 464 | 2.4 | −2.08 |
| Lack of knowledge of specific skills | 62 | 13 | 402 | 87 | 464 | 1.7 | −16.47 |
| Not available nearby | 126 | 27 | 341 | 73 | 467 | 2.2 | −10.90 |
| Did not learn while young enough | 77 | 19 | 337 | 81 | 414 | 2.0 | −16.00 |
| Parental disapproval in childhood | 28 | 6 | 436 | 94 | 464 | 1.2 | −37.50 |

* Minus sign indicates that the direction of the difference is away from the restriction or less than parameter value.

Opportunity was given to each family to list additional restricting factors that affect their family recreation program. These are listed in Table 11.

*The Relationship of Attitude To Family Recreation.* It was indicated in the introduction of this study, but not presented in this digest that the "attitude" of the church, the home, and even society through its civil laws, has had a marked effect on the use of leisure throughout the ages.

Each family develops an attitude towards leisure and its use. This attitude in the family situation becomes, ultimately, a state of readiness which exerts a directive and sometimes compulsive influence on the family as a unit. Eventually the responses become a definite part of the family reactions. There is reason to expect that various individual members of the family may have "selfish" attitudes towards specific activities. The family problem then becomes

one to reconcile the individual interests with those that are for the good of the entire family.

TABLE 11

*The Restrictions that were Added, by the Families Reporting, to Those Listed in the Questionnaire*

| Restriction | Frequency of Mention | Percentage of All Mentions |
|---|---|---|
| Age of children | 28 | 16.6 |
| Too tired | 21 | 12.5 |
| Rented apartment | 17 | 10.2 |
| Home too small | 14 | 8.3 |
| Children away at school | 11 | 6.6 |
| Baby sitter problem | 11 | 6.6 |
| Different family interests | 10 | 5.9 |
| Lack of planning | 10 | 5.9 |
| Wife dead | 6 | 3.5 |
| Family separated | 6 | 3.5 |
| Family grown up | 5 | 2.9 |
| Elderly parents | 5 | 2.9 |
| Cannot use yard | 4 | 2.5 |
| Too far from city | 4 | 2.5 |
| Father not interested | 3 | 1.8 |
| Anti-social tendencies | 3 | 1.8 |
| Lethargy | 2 | 1.2 |
| No playmates | 2 | 1.2 |
| Husband drinks | 2 | 1.2 |
| Only child is spoiled | 2 | 1.2 |
| No interest | 1 | .6 |
| Total | 167 | 100.0% |

Table 12 indicates that there was a statistically significant difference between the percentages of families reporting, they that were satisfied with their family recreation program and those who felt their program was unsatisfactory. Since their differences are statistically significant some specific factor or factors, rather than chance, determine the family attitude toward the recreation program.

TABLE 12

*The Attitudes of 466 Families Toward their Recreation Program*

| Attitude Toward Family Recreation Program | Number of Families Reporting | Families; Per Cent of Reporting | S.E. of % | $t$ Ratio |
|---|---|---|---|---|
| Satisfactory | 194 | 41.6 | 2.4 | 2.91 |
| Unsatisfactory | 272 | 58.4 | | |
| Total | 466 | 100.0% | | |

RECREATION AND THE UNIFICATION OF THE FAMILY

The family has long been the bulwark of society; a fundamental unit for intellectual and moral education as well as for social understanding and growth.

So long as the family concerns itself with problems that have an effect on the improvement of society every effort must be made to strengthen and vitalize it. If recreation can serve as a unifying agency it should take its place along with other interests and customs vital to family life.

Of the families studied, 69 per cent (S.E. .022) felt that they had achieved stronger family unity as the result of participation in family recreation programs.

Table 13 indicates, by income level, the activity classifications which provided activities that aided in this unification of the family.

TABLE 13

*A Listing, According to Income Level, of the Percentages of Families that Felt their Families Have Been Unified by Participation in Various Types of Recreational Activities*

| Activity Classification | Under $3000 % of Partn. | $300–4000 % of Partn. | $4000–5000 % of Partn. | $5000–6000 % of Partn. | $6000–7000 % of Partn. | $7000–8000 % of Partn. | $8, 00–10,000 % of Partn. | $10,000 & over % of Partn. |
|---|---|---|---|---|---|---|---|---|
| Sports | 27 | 24 | 10 | 19 | 33* | 20 | 14 | 25 |
| Nature & outing | 25 | 45 | 47 | 46 | 23 | 60* | 21 | 41 |
| Spectator sports | 4 | 7 | 5 | 4 | 2 | 0 | 24* | 5 |
| Spectator activities | 4 | 2 | 0 | 3 | 5* | 0 | 5* | 2 |
| Social activities | 15 | 8 | 25* | 7 | 16 | 10 | 19 | 10 |
| Music, mental, drama partn. | 18* | 12 | 0 | 13 | 14 | 0 | 9 | 17 |
| Arts and crafts | 1 | 0 | 3 | 7* | 2 | 0 | 5 | 0 |
| Organizational interests | 4 | 2 | 10* | 1 | 0 | 10* | 0 | 0 |
| Collecting items | 2* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total per cent | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

* Indicates the highest percentage of participation in the classification.

It is interesting to note that there is a trend which apparently indicates a close relationship between the family income level and the nature of the unifying activity. In other words, those families that have higher incomes tend, for the most part, to participate in activities which have higher participation costs, require a car, or need other high cost equipment.

Table 14 gives a rank order of the activities mentioned as most frequently being used in the unification of the family. Since attitude is an important factor, two ranks are made for comparison.

The rank order correlation between these two lists is exceptionally low, (inferred $r$ value is .094 with a P.E. of .17). This offers rather conclusive evidence that the types of programs that are unifying for those who consider their programs to be satisfactory are quite different from those of the families that feel their programs are unsatisfactory.

TABLE 14

*The Specific Activities Mentioned Most Frequently as Being of Considerable Value in the Unification of the Family*

| Families That Considered Their Recreation Programs to Be: | |
|---|---|
| Satisfactory | Unsatisfactory |
| *Rank* | *Rank* |
| 1. Swimming | 1. Card Playing |
| 2. Outing activities | 2. Reading |
| 3. Outdoor sports | 3. Spectator sports |
| 4. Music-family singing | 4. Outing activities |
| 5. Auto riding | 5. Swimming |
| 6. Entertaining guests | 6. Church activities |
| 7. Barbecues | 7. Horseback riding |
| 8. Excursions | 8. Outdoor sports |
| 9. Reading | 9. Entertaining guests |
| 10. Card playing | 10. Music-family singing |
| 11. Gardening | 11. Barbecues |
| 12. Church activities | 12. Photography |
| 13. Photography | 13. Auto riding |
| 14. Handcraft | 14. Excursions |
| 15. Spectator sports | 15. Gardening |
| 16. Horseback riding | 16. Handcraft |

## Summary

At the completion of the survey an analysis of the data indicates the following to be the findings:

1. A study of the percentages of families having specified incomes indicates that the sample is not significantly different from the national figures established by the United States Bureau of the Census.

2. The questionnaire was determined, by means of statistical analysis, to be a valid and reliable instrument for the purposes of this study.

3. The rank, according to frequency of participation, of the various types of family recreational activities is as follows:

Nature and Outing Activities
Spectator Activities
Social Activities
Participation in Sports and Games
Spectator Sports (watching)
Participation in Music, Mental and Drama Activities
Organizational Interests
Participation in Arts and Crafts
Collection of Items

4. The forms of activities most frequently used are those that are not highly organized and require little, if any, advance or preliminary preparation.

5. The number of family recreational activities ranged from zero to 74, with a median of 21.

6. The data indicate that the great majority of the families have few interests in common and that the major amount of participation occurs in a wide range of activities.

7. Of all the family recreation, 51 per cent (S.E. .498) takes place away from the home.

8. The more formalized and regimented activities where participation is controlled by rule and custom are preferred to those that allow for greater initiative and self-direction.

9. There is an increase in the mean number of recreational activities in use by the families as their income level rises to $7,000 per year.

10. As the family income rises above $7,000 per year, there is a gradual "tapering off" in the mean number of family recreational activities until the families in the "Over $10,000" bracket approximate the mean for the $3,000 per year group.

11. The families with incomes ranging from $5,000 to $8,000 per year were, as a group, most satisfied with their recreation program.

12. A significant percentage (62%; S.E. 3.1) of the families in the two lowest income groups feel that their recreation program is unsatisfactory.

13. Seventy-five per cent ($t$-ratio 10.65) of the families feel that their recreation program is restricted by one or more factors.

14. None of the factors which were listed as possible restrictions to good family recreation programs were proven to be statistically significant.

15. The families that report an unsatisfactory program of family recreation know which factors restrict their program.

16. Fifty-eight per cent (S.E. 2.4) of the families felt that their recreational program was unsatisfactory.

17. Sixty per cent (S.E. 2.2) of the families feel they have achieved stronger family unity as the result of participation in family recreation programs.

18. There are no differences, other than in the rank order of frequency of use, between the programs of the families that report their programs to be satisfactory and those that feel theirs is unsatisfactory.

19. The families which report a satisfactory program obtain greater unification values from those activities that require active and strenuous participation.

20. Of the families who want additional specific recreation opportunities for their families, 74 per cent (S.E. 4.0) prefer those that require active or strenuous physical activity.

21. A significantly greater percentage of the families want opportunities for participation in Nature and Outing Activities more than in any other type of activity.

22. The nature of the activities which are reported as being of value in the unification of the family are usually rather closely related to the income level of the family.

**Conclusions**

There are some very definite conclusions which may be drawn from this study of family recreation. These conclusions fall, quite naturally, into the

three distinct areas that were indicated as the purposes of the investigation.

1. The types of activities most frequently used in the family recreation program are those that are not highly organized and require little if any advance or preliminary preparation.

2. The data indicate that the great majority of the families have few interests in common and that the major participation occurs in a wide range of activities.

3. There are no statistically significant factors that serve universally to deter or restrict family recreation.

4. A significantly high percentage of the families felt they have an unsatisfactory recreation program.

5. A significant percentage of all families feel they have achieved stronger family unity as the result of participation in family recreation programs.

6. The forms of family recreation that serve better than others in the unification of the family are those that call for either strenuous or active participation.

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8. TRIBBLE, DR. HAROLD W., at Convocation Ceremonies marking his formal introduction as new president of Andover-Newton Theological School, Newton Centre, Mass., Sept. 17, 1948.
9. U. S. Department of Commerce, Bureau of Census. *Current Population Reports; Consumer Income*. Series P-60, No. 3, Washington, D. C., June 1948.
10. U. S. Department of Commerce, Bureau of Census. *The Labor Force. Population*, Vol. III, Part I, United States Summary, Washington, D. C., 1940, p. 11.
11. White House Conference on Child Health and Protection. As reported in *The Adolescent in the Family*. New York: D. Appleton-Century Co., 1934, p. 167.

# Research Abstracts

*Continued from the March Quarterly*

**Prepared by the Research Abstracts Committee of the National Council of the Research Section, *Paul A. Hunsicker, Chairman***

## Anatomy and Physiology

22. Chiodi, Hugo. El Instituto Biología de la Altura. *Ciencia e Investigación*, **8:** 134–137 (1952).

In 1951, an institute for studying biology at altitude was officially opened at Mina Aguilar, Provincia de Jujuy, Argentina, 4000 m. above sea level. The director of this institute is Dr. Hugo Chiodi. Among various investigations so far conducted by this institute are: the effect of altitude on the blood picture, on the sensitivity of the respiratory center, on physical and chemical equilibrium of the blood, and the effect of anoxia on the heart. Physical education organizations were also interested in this institute before it was officially opened. The National Sports Commission of Bolivia sent Dr. Luis Otero Calderon there to conduct scientific investigations. The building was donated by Compañía Minera Aguilar.—*Peter V. Karpovich.*

23. Chiodi, Hugo, and R. Sammartino. Fatty liver degeneration in young rats caused by high altitude. *Cienci e Investigación*, **8:** 462–465 (1952).

White rats born at an altitude of 13,095 feet die, as a rule, within 10–17 days after birth. They all exhibit disturbances of growth and development. The most striking finding in these rats is a fatty degeneration of the liver. Of 486 newborn rats, only 7 lived more than a month, although one of them reached the age of 100 days. If rats are placed immediately after birth into a pressure chamber where the air pressure is equal to that at sea level, and kept there for 30 days, the degeneration of the liver is prevented and the rats continue to develop normally. These observations thus prove that the liver condition and death are due to hypoxia. —*Peter V. Karpovich.*

24. Chiodi, Hugo, L. O. Calderon, and J. R. Suárez. Sensitivity of the respiratory center at high altitude. *Ciencia e Investigación*, **8:** 466–469 (1952).

Eleven men who had lived at an altitude of 4500 m. for at least four years were investigated. They all had greater respiratory rate and greater pulmonary ventilation than the average at sea level. When these people were given pure oxygen to breathe, it had very little effect on the acquired pulmonary hyperventilation. Breathing carbon dioxide (20 mm. Hg) had the same effect as on people at sea level, indicating that the sensitivity of the respiratory center remains normal.—*Peter V. Karpovich.*

25. Dublin, Louis I. Overweight, America's No. 1 Health Problem. *Today's Health*, **30:** 18–22 (Sept. 1952).

Recent statistics indicate that about 25 million people in our country are overweight to some degree and at least 5 million adults are seriously obese. Overweight predisposes large numbers of people to high blood pressure, diabetes, difficulties during and after pregnancy, cancer of the liver and gallbladder, and other disorders. A weight-reduction program was started among the employees of the Metropolitan Life Insurance Company and the mortality statistics compared with an overweight group. Among the men the mortality was cut about ⅕ and among the women more than ⅓. Prevention of overweight should begin in childhood. The fact that fat runs in families is more often due to the poor example set by the parents than it is to inheritance.—*J. Grove Wolf.*

26. EDITORIAL, Medical examination for athletes. *J.A.M.A.*, **150:** 1490–1491 (Dec. 13, 1952).

Medical examinations in the State of New York revealed that many aspirants for boxing had syphilis, cardiac disease, hypertension, chronic nephritis, diabetes, and "latent medical, traumatic and neurological conditions." Since 1946, 87 men have died after boxing bouts, 47 of them in the United States. The number of men who became "punch drunk" is not known, but this type of injury represents the most important occupational hazard of boxers. It is for society to decide whether professional boxing should continue or not. The medical profession should, however, insist on a thorough examination of men before the boxing match.—*Peter V. Karpovich.*

27. GAVAN, J. A., S. L. WASHBURN, AND P. H. LEWIS. Photography: an anthropometric tool. *Am. J. Phys. Anthrop.* **10:** 331–353 (Sept. 1952).

A large part of the error inherent in traditional systems of measurement and observation can be eliminated by photography. Photography has not been used freely in the past because it has been more difficult to convert the photographic measurements than to measure directly.

The problem of paper shrinkage, inadequate lighting and distortion can be eliminated with adequate planning for the specific purpose of producing a standard scale picture suitable for measurement and observation. Distortion can be reduced to less than the error of measurement by using a long lens-subject distance and, by the use of a reduction ratio, the photographic measurements can be reduced to actual measurements.

There was a close relationship between photographic and traditional measurements for two subjects. Some of the measurements were better adopted to photography than others. It was indicated that many problems could be solved by photographic measurement alone.

Explicit instructions for the entire photographic process as it applies to anthropometry are given.—*F. Sills.*

28. HÖGBERG, PAUL. Length of stride, stride frequency, "flight period" and maximum distance between the feet during running with different speeds. *Arbeitsphysiologie.* June 1952, pp. 431–436.

The investigations were conducted at running speeds of from 8 to 30 km/hr on a treadmill. The subjects were two well-trained runners. The length of stride was defined as the distance between the foot marks on the track, stride frequency as the number of strides per minute, and the flight period as the time when the body was clear of the ground. The maximum distance between the feet was measured from the toes of the front foot to the part of the back foot that went farthest back (while in the air).

It was found that at low speeds a runner increases his speed by increasing length of stride. At faster speeds, which varied for different runners, the speed was increased by an increase of stride frequency. The subjects reached a maximum for length of stride of 210–218 cm. while the maximum distance between the feet (measured in the air) was 150–155 cm. The author concluded that the leg drive and not leg length was of greatest importance in lengthening the stride during fast running. The "flight period" at the farthest speeds were about 45 to 50% of the whole stride.—*F. Sills.*

29. JONES, HAROLD E. Research on aging: proceedings of a conference held on August 7–10, at the University of California, Berkeley. New York: Social Science Research Council, 1950, iii, 128 pp. (mimeo).

The published proceedings include both the papers and the subsequent discussions. A total of 25 papers covered a wide range of problems of aging; represented are ". . . psychology, physiology, and various social sciences, and also . . . medicine, public health, social welfare, and jurisprudence." The proceedings serve to outline current research on aging, type of problem being studied, methods, and something of the theory behind current studies.—*Psychological Abstracts.*

30. MILLER, A. T. JR., H. L. PERDUE, E. L. TEAGUE JR., AND J. S. FEREBER. Influence of oxygen administration on cardiovascular function during exercise and recovery. *J. Applied Physiol.*, **5:** 165–168 (1952).

Nine athletes and 17 non-athletes exercised on a motor-driven treadmill, both groups moderately and the athletes also to exhaustion. Oxygen was given in 3 ways: (1) for 10 minutes before, (2) during, and (3) for 20 minutes after exercise. Heart rate and blood pressure during exercise and rate of return to normal were not affected. The formation of lactic acid was also not affected by $O_2$ given before or after exercise, but giving it *during* exercise significantly decreased blood lactate in athletes both during moderate and exhausting exercise. It did not significantly decrease lactate concentration of non-athletes during moderate exercise. $O_2$ administration during exercise increased endurance in athletes.—*Lora M. Ewing.*

31. MILLMAN, MAX. Weight, heart and blood pressure. *Today's Health*, **30:** 28–29, 52–53 (Nov. 1952).

Heart disease is aggravated by obesity. Statistics from life insurance companies show that disease of the heart and arteries is 50% more common in the overweight than in the normal. The heart contracts more than 100,000 times a day, pumping seven or eight tons of blood a day through arteries and capillaries to every part of the body. It has been estimated that for every 20 pounds of excess weight and the resultant increase in the number of new capillaries, this would mean 12 extra miles of vessels through which the blood would circulate. In 1951, diseases of the heart and blood vessels were responsible for more deaths than all other diseases combined. Medical science has found that the prevention and correction of obesity slows the progression and frequency of such diseases, therefore increasing the span of human life expectancy.—*J. Grove Wolf.*

32. NEUWIRTH, E., M.D. Cervical spine disorders and head pain, *Mod. Med.*, Jan. 15, 1953, pp. 106–107.

Pressure on cervical spinal roots can cause somatic elusory, motor, and sympathetic symptoms. Traction is usually the most effective procedure.

Cervical diskopathy may produce a syndrome of cervicalbrachialgia, diminution of cutaneous sensibility, decreased muscle reflexes. Additional symptoms, not limited to root areas and apparently sympathetic, are precordial distress simulating heart disease, vascular pains, sensations of heat and cold in the fingers, hand and forearm, and facial and cranial pains.

Roentgenograms may show loss if lordotic curvature of cervical spine, herniation of nucleus pulposus, vertebral displacement, hypertrophy of the yellow ligaments, or new bone formation. About 70% of patients treated by traction recover or improve greatly. When cord compression is imminent, and traction gives no relief, neurosurgical intervention may be necessary.—*Frank Sills.*

## Education

33. BACH, JACOB O. Practice teaching success in relation to other measures of teaching ability. *J. of Experimental Educ.*, **21:** (1) 57–80 (Sept. 1952).

Correlational analysis was utilized to determine the relationship between success in practice teaching and success in the first year of teaching. Seventy-six students were visited and rated as to classroom performances. School principals were interviewed and ratings secured for each beginning teacher. Academic, intelligence, practice teaching, and other records were obtained from university files. It was found that the relationship between practice teaching ability and success in the field are negligible. The author states that critic teachers and principals are emphasizing different characteristics or abilities in the people they train and hire, or else they place different values upon and seek different combinations of the same abilities.—*D. B. Van Dalen.*

34. GUILFORD, J. P. When not to factor analyze. *Psychological Bulletin*, **49:** 26–37 (1952).

The following errors frequently occur in factor analysis: (1) too many or not enough factors are extracted for the number of experimental variables involved; (2) too many experimental variables are factorially complex; (3) common factors are undetected because present in only one experimental variable or a pair of factors is very much confined to a set of experimental variables so that no test having variance in one of the factors is free of variance in the other;

(4) spurious correlation coefficients are employed, including those between ipsative scores and those for which requisite assumptions are not met; (5) heterogeneous populations are analyzed; (6) substantial variation in test difficulty-level occurs. The occurrences of these errors in analyses of standard tests is discussed.—*Psychological Abstracts.*

35. RINGNESS, THOMAS A. Relationships between certain attitudes towards teaching and teaching success. *J. of Experimental Educ.*, **21:** (1) 1–55 (Sept. 1952).

One hundred men and women undergraduates were studied to discover common factors which underlie the choice of teaching as a profession, to determine the adequacy of several instruments to reveal comparable data, and to investigate the relationship between reasons given for choice of profession and subsequent teaching success. Factor analysis, techniques and multiple correlations were employed for variables involved. The Strong Vocational Interest Blank results bore no relationship to teaching success in this study. Results of the study indicate that teachers are motivated to teach by different wants, reasons, and values. Teaching success is related to the nature of the reasons for choice in teaching.—*D. B. Van Dalen.*

36. WALTERS, RAYMOND. Statistics of attendance in American universities and colleges, 1952. *School and Society* **76:** 385–398 (Dec. 20, 1952).

The annual statistical report from 830 approved universities and four-year colleges throughout the United States is analyzed in regard to full and part-time students and teaching staff. Some enrollment trends are discussed.—*D. B. Van Dalen.*

37. Facilities survey discloses one-fifth of pupils in unsafe schools. *J. School Health*, **22:** 9 (Nov. 1952).

This article is a reprint from *Safety Education* (Oct. 1952) and is a summary of the First Progress Report of the School Facilities Survey being conducted by the United States Office of Education under the direction of the Eighty-first Congress.

Findings include: Almost 70 percent of the school buildings in 17 states which have completed the study on fire resistiveness are classified as combustible; 21 per cent of the pupils are enrolled in buildings not meeting the fire safety conditions outlined in the report; and 87 per cent of the classrooms in 25 states fail to provide the recommended minimum of 30 square feet of floor space per pupil. Many school children are housed in firetraps, which are dilapidated, overcrowded, and generally ineffective educationally.—*John H. Shaw.*

## Physical Education

38. BELICHICK, STEVE. Varsity Play and Test Results in Basketball. *Athletic Journal*, **33:** 22, 50–51 (Nov. 1952).

The author proposed to discover whether the scores made on the Knox Basketball Ability Test are indicative of a player's ability to perform the same skills under game conditions. The Knox test is comprised of the speed-dribble test, wall-bounce test, dribble and shoot test, and the penny-cup test. Scoring in this test is on the basis of the amount of time required to complete all the events. The performance of these same skills were charted throughout an entire 19-game season. Objectivity coefficients of correlation ranged from +.93 to +1.00 for the six recorders. The conclusion is that there is little consistency of the score the player makes on the Knox test and the performance of the skills under game conditions.—*J. Grove Wolf.*

39. CHILDS, JOHN P. Safety Method in a Football Administration. *Athletic Journal*, **33:** 20, 52–55 (Oct. 1952).

Previous studies by Lloyd and Eastwood on football injuries found that the leg and foot area accounted for 43% of all injuries, with the knee and ankle being the parts most frequently injured. Sprains ranked first among the types of injuries, accounting for 53.4% among high school injuries. A thorough physical and medical examination before the season starts, along with subsequent examinations, would do much to alleviate many of the injuries received. The football coach is the most important factor in the safety and welfare of his team. Adequate safety equipment, careful scheduling of games, a limited number of games, and stress on basic fundamentals of play also should not be neglected.—*J. Grove Wolf.*

## Recreation

40. Blacktop for apparatus areas? *Recreation*, **46:** 1: 19 (April 1952).

A questionnaire was sent to the elementary school principals in Portland, Oregon. The questionnaire requested their opinion regarding playground apparatus, "hardsurfaced" areas, and apparatus accidents on school playgrounds. The findings of the survey were based on an analysis of the 66 returns received.

Some findings of the study were as follows: (1) with the exception of three schools, all are equipped with hardsurfaced areas; (2) the hardsurfaced areas vary considerably in size; (3) a large majority of the principals recommended that a substantial area of the playground be hardsurfaced; (4) of the 226 pieces of playground equipment reported by all principals, 151 (67%) are installed on blacktop surface; (5) a large majority of the principals stated that they would advise installation of playground equipment on school playgrounds; (6) a majority of the principals stated that they would recommend hardsurfacing under playground equipment installed; (7) of the 275 accidents attributed to playground equipment during the school-year 1950–51, 172 (63%) occurred at schools where playground equipment was not installed on blacktop; (8) although 67% of playground equipment is installed on blacktop, the returns indicated that only 37% of all accidents can be attributed to playground equipment; (9) in relation to the number of units installed, traveling rings and horizontal bars are the most dangerous types of playground apparatus.—*Jackson M. Anderson.*

41. Concessions, fees, and charges. *Recreation*, **45:** 9: 506–508 (Feb. 1952).

In October 1950, the Department of the Interior issued a report prepared by an impartial, expert, and non-governmental committee designated the Concessions Advisory Group of the National Park Service. This committee report was based on a study of the policies governing concessions within areas administered by the Service.

The following are a few of the committee's recommendations which have been approved by the Department of the Interior: (1) it shall be the policy of the department to permit the development of accommodations within the areas administered by the National Park Service only to the extent that such accommodations are necessary and appropriate for the public use and enjoyment of the areas, consistent with their preservation and conservation; (2) the number of sites and the locations and sizes of the tracts of land assigned for necessary accommodations shall be held to the minimum essential to proper and satisfactory operation; (3) as for merchandising within the areas administered by the National Park Service, it shall be limited, in general, to those items and services appropriate or necessary for the public use and enjoyment of the areas; (4) automotive transportation service shall be authorized in areas administered by the National Park Service only to the extent necessary to make the areas and their features available to the visiting public.—*Jackson M. Anderson.*

42. Garbee, Eugene E. Basic craft principles. *Camping Magazine*, **24:** 2: 26 (Feb. 1952).

A survey was made of 128 camps located in 17 eastern states. Of the total, 65 were agency camps and 63 private camps. The purpose of the study was to determine those principles which are most important in conducting a successful camp crafts program. The respondents were asked to indicate whether each craft principle was essential, desirable, useful, or unnecessary.

The following principles, listed in order of importance, were rated essential: (1) safety procedures should be stressed for each craft project; (2) the head crafts counselor should be specially trained in crafts; (3) senior campers (ages 14 and up) should be permitted to select their own projects. The following principles, listed in order of importance, were rated desirable: (1) intermediate campers (ages 10 through 13) should be permitted to select their own projects; (2) native crafts materials should be used in the crafts program; (3) crafts facilities should be available to campers during "free periods;" (4) crafts periods should be scheduled by camper age groups; (5) the head crafts counselor should be of the same sex as the campers; (6) junior campers (ages 6 through 9) should be permitted to select their own projects; (7) crafts materials for the entire season should be purchased before camp opens; (8) power tools should be provided for use of senior campers.—*Jackson M. Anderson.*

# Guide to Authors

IN LINE with the over-all goal of making Association publications yield the greatest value to the individual and the profession, the following is a guide for the preparation of research manuscripts. The information below recognizes general techniques being employed by research publications similar to the *Research Quarterly*. When copy is prepared in accordance with these instructions, all Association research studies will follow a standard style.

**Manuscripts**

Manuscripts should be sent to the Editor (AAHPER, 1201 Sixteenth Street, Northwest, Washington 6, D. C.), who will see that each one is read by at least three members of the *Research Quarterly* Board of Associate Editors. On the basis of the three reviews, the Editor will advise the author as to the suitability of the paper or the desirability for revision. Papers are not judged by arbitrary standards but on their content of new research results in the field of physical education, health education, and recreation, presented with the greatest brevity compatible with scientific accuracy and clarity.

Since three members of the Board of Associate Editors review an article, it is requested that three clear copies of the manuscript be submitted in order to facilitate reviewing. A fourth copy of the article should be retained by the author. Only one copy of any charts, photographs, drawings, graphs, or similar illustrative material need be submitted. However, since such material must be sent to each reviewer in turn, more time must be allowed for the reviews.

Typewritten manuscript should be double-spaced on white paper of ordinary weight and standard size (8½ x 11 inches).

The sheets of manuscript should be kept flat and fastened with clips which can be removed easily. The pages of the typewritten copy should be numbered consecutively in the upper right-hand corner.

Paragraphs should be numbered consecutively throughout the manuscript, to facilitate ease of reference in case of revision.

**Headings**

The article should be arranged so as to indicate relative values of heading and subheadings.

Usually four gradations are sufficient: (a) article title, (b) first subhead appearing in boldface aligned left on page (underscored in manuscript with wavy line), (c) second subhead (if necessary) appearing in small caps aligned left on page, (d) third subhead, to appear in italic (underscored in manuscript), not centered, but run in at the beginning of the paragraph or section.

All headings should be typed in lower case with initial capitals, except for (c) above, which should be typed in capital letters.

## Documentation

### FOOTNOTES

Footnotes are not to be used for references or literature citations. They are rather used for the purpose of acknowledgment, special explanation, supplementary information, etc. (*See examples below.*)

Type footnotes (if any) on separate sheets, as many footnotes as convenient being written on a sheet. Footnotes should be numbered from 1 up for each article; a corresponding numeral appearing in the text. Asterisks should not be used.

*Examples of Footnotes:*

[1] This study was made under the direction of Dr. Arthur T. Slater-Hammel in the Research Laboratories, School of Health, Physical Education, and Recreation, Indiana University, Bloomington, Indiana.

[2] All measurements of the hand were recorded in centimeters and height was recorded in inches. The hand measurements were taken by Everett and reliability coefficients of above .90 were found for each measurement used in the study.

[3] For their wholehearted co-operation in facilitating collection of the data, special gratitude is extended to Superintendent Clarence Hines and the 1950–51 principals of the Adams, Condon, Edison, Francis Willare, Harris, Howard, Lincoln, River Road, and Whiteaker schools.

### CITATIONS OF LITERATURE

Citations of literature should be segregated alphabetically by author's last name at the end of each article, under the caption of "REFERENCES." *Do not treat them as footnotes.* (*See above.*)

The literature citations, listed alphabetically, should be numbered consecutively, their location in the text being indicated by corresponding numbers written in full size and enclosed in parentheses: for example, (1) (2, 3). If there are several references in the text to a citation, the specific pages may be indicated thus: (1, *p. 117*) (1, *pp. 162–3*).

A uniform style should be maintained in writing citations. Do not enclose titles of chapters and articles in quotation marks. Italicize (underscore in manuscript) names of books and periodicals, bulletins, etc. (*See examples below.*)

Uniform sequence of data should be observed, as follows: *For a book*—Author's name (last name first); title of article or chapter; name of book; place of publication; publisher; year date; number of pages or specific pages referred to. *For a periodical*—Author's name (last name first); title of article or chapter; name of periodical; volume number; page numbers; year date; specific pages (if any).

*Examples of References Appearing at End of Article:*

1. American Association for Health, Physical Education, and Recreation, Health Education Division, Suggested Platforms for Health Education, *Journal of the American Association for Health-Physical Education-Recreation*, **18:** 436 (Sept. 1947).

2. American Association of School Administrators. *Health in Schools.* Revised edition. Washington, D. C.: the Association, a department of the National Education Association, 1951. pp. 266–7.
3. DEAVER, G. G., Exercise and Heart Disease. *Research Quarterly,* **26:** 24–34, 1939. p. 26.
4. OGDEN, JEAN, AND JESS OGDEN. *Small Communities in Action.* New York: Harper & Brothers, 1946. 244 pp.
5. POTTER, JOHN NICHOLAS. *Physical Fitness of Junior High School Boys.* Unpublished Master's thesis, University of California, Berkeley, 1942. 39 pp., p. 15.

**Tables**

Each table should have a descriptive heading and should be specifically referred to in the text by number, *e.g.*, "Table 10," etc., never as "the above table" or "the following table." Number tables from 1 up for the entire manuscript, using Arabic numerals.

Tables should be double-spaced typewritten, like the rest of the material in the manuscript. They should be typed on separate sheets, as the printer will set them on a different machine from the one used for the text matter. If a table continues on a second sheet, it is not necessary to repeat the boxheads, the printer repeating when necessary from the original boxheads.

The word "TABLE" should be written in capital letters, as: "TABLE 1"; the table title should be written in lower case letters with initial capitals, and centered over the table. Tables should be ruled as desired, except that no rules will appear at the extreme right and left edges of the table. No double rules are to be used, unless necessary for clarity.

**Illustrations**

Illustrative material is of two types: pen and ink drawings, which are reproduced by the line engraving process; and photographs, wash drawings, stipple drawings (in short anything containing shading), which are reproduced by the halftone process.

Line engravings are always treated as text figures and should be so designated. All drawings should be made with India ink, preferably on white tracing paper. If graph paper is used, a blue-lined paper must be chosen, as all other colors will make the graph lines appear in the background; sometimes it is desirable to ink in inch squares so that the curves can be more easily read.

Lettering should be plain and large enough to reproduce well when the drawing is reduced to the dimensions of the printed page ($4\frac{1}{8}$ x 7 inches). Most figures can be advantageously drawn for a linear reduction of one-half or one-fourth. Explanatory lettering should be included within the chart. Do not use gummed letters, for they are easily lost.

Care should be taken not to waste space, as this means greater reduction and a less satisfactory illustration. Often it is possible to combine several curves in one figure and thus not only save space but enable the reader to make comparisons at a glance. Legends can often be included within the chart and a considerable saving in space thus effected.

Halftones are treated as figures and should be so designated. Frequently, several halftones can be grouped to form an attractive full page, in which

case they should be numbered consecutively, in Roman numerals. Photographs should be in the form of clear black and white prints on glossy paper. Care should be taken to see that they cannot be bent or folded in handling *and paper clips should not be used.* All imperfections in the original copy are reproduced.

Figures should each be numbered consecutively from I up for the entire manuscript. Use Roman numerals to number figures, and Arabic numerals to number tables. The legends for the illustrations should be typed upon a separate sheet placed at the end of the manuscript. Care should be taken to indicate plainly in the text the exact location of all illustrations and tables.

The Association will assume complete engraving expense.

## Special Points of Style

### USE OF NUMBERS

Use Arabic figures for all definite weights, measurements, percentages, and degrees of temperature (for example: 2 kgm., 1 inch, 20.5 cc., 300°C.). Spell out all indefinite and approximate periods of time (for example: over one hundred years ago, about two-and-one-half hours). For numerals used in a general sense, spell out numbers through ten and use Arabic figures for 11 and over (seven times, five years old, 11 students).

### ABBREVIATIONS

The metric system being in universal usage, standard abbreviations should be used whenever the weights and measurements are used with figures, i.e., 10 kgm., 6.25 cc., etc. The forms to be used are: cc., kgm., mgm., mm., l., and m. *Gram* should be spelled out in all cases to avoid possible confusion with *grain.* All obscure and ambiguous abbreviations should be avoided. Spell out English weights and measures (for example: ounce, pound, inch, foot, yard, mile). Preserve uniformity in all abbreviations.

Per cent should be two words. Use per cent sign (%) in tables or when it appears in parentheses in text.

## Proofreading

The author will receive his original manuscript and any engraver's proofs with the galley proofs of his article for correction. A reprint order blank will be enclosed for the author's convenience.

Errors that are discrepancies in transcription from the manuscript should be marked in *red* ink; any changes from copy should be marked in *black* ink. These two classes of errors are handled at the printer's by different operators.

Authors should be sure to answer all queries addressed to them on the proof. Any instructions to the printer should appear on the proof itself. If instructions are too extensive to write on proof, they may be embodied in a letter. Instructions and answers to queries should be circled to avoid the possibility of mistaking them for new copy.

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